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**Research Report 1773**

**Cognitive Psychology Principles  
for Digital Systems Training**

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## FOREWORD

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The Future Battlefield Conditions (FBC) Team of the Armored Forces Research Unit (AFRU), U.S. Army Research Institute for the Behavioral and Social Sciences (ARI) has a work package (211) FUTURETRAIN: Techniques and Tools for Command, Control, Communications, Computers, Intelligence, Surveillance, and Reconnaissance (C4ISR) Training of Future Brigade Combat Team Commanders and Staffs. Recent work under this work package has involved research and development concerning training for digital staffs.

This report identifies training program techniques based on principles of cognitive psychology that could be incorporated into Computer-Implemented Training (CIT) modules to enhance the acquisition, retention, and transfer of future digital Command, Control, Communications, Computers, and Intelligence (C4I) system commander and staff skills. The research 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 theories of learning might be applied to modify training to enhance skill retention. The present work identifies opportunities to apply principles of cognitive psychology in developing prototype CIT modules for the Force XXI Battle Command Brigade and Below (FBCB2) digital information system.

The information provided in this report is valuable to the U.S. Army Armor School (USAARMS) and other organizations involved in developing CIT for soldiers and leaders. The cognitive psychology principles for digital information system training design identified in this report are applicable to a wide range of current and future systems. The results of this research were briefed to representatives of the USAARMS, Directorate of Training and Doctrine Development, and other Fort Knox agencies during an In-Process Review on 1 February 2001.

ZITA M. SIMUTIS  
Technical Director

# COGNITIVE PSYCHOLOGY PRINCIPLES FOR DIGITAL SYSTEMS TRAINING

## EXECUTIVE SUMMARY

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### Research Requirement:

As the Army transitions to new digital technologies, it faces a major challenge in developing integrated training programs that support the acquisition and retention of the skills required to exploit the capabilities of these systems. The goal of the present research effort is to identify training program techniques based on principles of cognitive psychology that can be incorporated into Computer-Implemented Training (CIT) modules. Incorporation of these techniques can enhance the acquisition, retention, and transfer of future digital Command, Control, Communications, Computers, and Intelligence (C4I) system skills.

### Procedure:

A literature review was conducted to identify key cognitive psychology principles that support the acquisition, retention, and transfer of skills. The product of this literature review was a preliminary set of cognitive psychology principles and related training techniques applicable to digital skills training. A representative Army digital C4I system was identified that could be used to identify task skill requirements. Software for the Force XXI Battle Command Brigade and Below (FBCB2) digital information system was obtained and loaded onto computers provided by the Fort Knox Mounted Maneuver Battlespace Lab (MMBL). A hands-on walk-through of selected FBCB2 tasks was conducted to refine the description of cognitive training techniques that can be incorporated into CIT modules for digital C4I systems.

### Findings:

The products of this research are a set of cognitive psychology principles and related training techniques summarized in tabular form, and an outline for a training program structure. The tabled principles and techniques can be easily reviewed and discussed by training developers to facilitate training design. The products generated in this research should be useful for training developers in designing CIT for the FBCB2 system, and for a broad range of current and future digital C4I systems.

### Utilization of Findings:

The products and findings generated in this research should be directly applicable to Army efforts to develop CIT for the FBCB2 system, and for other current and future digital C4I systems. In a parallel contract effort, the summary tables of cognitive principles and training techniques developed in this research were used to develop prototype CIT modules for four FBCB2 tasks. These prototype training modules serve to demonstrate how the principles and techniques identified in the present research can be utilized in real world training development applications.

# COGNITIVE PSYCHOLOGY PRINCIPLES FOR DIGITAL SYSTEMS TRAINING

## CONTENTS

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	Page
INTRODUCTION .....	1
Requirement.....	1
Digital Task Environment.....	1
Cognitive Principles for Training .....	2
Automated Performance Assessment and Feedback .....	2
Research Hypotheses .....	3
Research Approach.....	3
Report Organization.....	3
SELECTING TASKS FOR TRAINING TECHNIQUES IDENTIFICATION.....	4
An Exemplar Digital Information System .....	4
Task Knowledge and Training Method Taxonomy .....	5
Task Analysis.....	5
FBCB2 Tasks Selected .....	6
LEARNING PRINCIPLES FOR TRAINING DESIGN.....	7
Introduction.....	7
Behaviorist Learning Principles and Techniques .....	7
Cognitive Learning Principles and Techniques .....	9
Constructivist Learning Principles and Techniques .....	13
Summary of Learning Principles and Training Techniques .....	17
Outline for a Training Module Structure .....	17
PROTOTYPE TRAINING MODULES.....	17
SUMMARY AND DISCUSSION.....	19
Summary .....	19
Research Hypotheses .....	19
Evaluating Training Effectiveness.....	21
Future Research Directions.....	21
REFERENCES .....	23

CONTENTS (Continued)

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	Page
APPENDIX A. List of Acronyms.....	A-1
B. Outline Of Screens for Essential Training Program Functions.....	B-1
C. Demonstration Mode Video Screen.....	C-1
D. Student Subject Matter Review Screen.....	D-1
E. Subject Matter Quiz Screen.....	E-1

LIST OF TABLES

Table 1. Taxonomy of Task Knowledge Type and Training Approach.....	5
2. Behaviorist Principles and Related Training Techniques.....	8
3. Cognitive Principles and Related Training Techniques.....	11
4. Cognitive Strategies and Related Training Techniques.....	12
5. Constructivist Principles and Related Training Techniques.....	15

LIST OF FIGURES

Figure 1. FBCB2 Screen showing map area and navigation menu.....	4
2. Prototype FBCB2 training screen.....	18

# COGNITIVE PSYCHOLOGY PRINCIPLES FOR DIGITAL SYSTEMS TRAINING

## Introduction

### *Requirement*

As the Army transitions to new digital technologies, it faces a major challenge in developing integrated training programs that support the acquisition and retention of the skills required to exploit the capabilities of these systems. Recent research documented concerns over the retention of digital procedural skills required to operate an Army digital communications system (Sanders, 1999). In that research, results showed a 52 percent reduction in the number of soldiers able to complete basic operator tasks 30 days after instruction. The need exists to integrate sound principles of cognitive psychology and instructional design into training development in an effort to enhance digital skill acquisition and retention. Modern digital Command, Control, Communications, Computers and Intelligence (C4I) systems tasks can be characterized as relatively dynamic with frequent changes introduced through computer hardware and software upgrades. The dynamic nature of digital C4I tasks thus requires the development of training programs that can efficiently adapt over time to evolving training demands.

The goal of the present research effort was to identify principles of cognitive psychology that could be incorporated as training techniques into Computer-Implemented Training (CIT) modules to enhance the acquisition, retention, and transfer of future digital C4I system battalion commander and staff skills. This research provided guidance and support to a parallel contract effort to design, develop, and demonstrate prototype training modules for the Force XXI Battle Command Brigade and Below (FBCB2) digital information system (Deatz & Cobb [in preparation]).

### *Digital Task Environment*

The U. S. Army Research Institute for the Behavioral and Social Sciences (ARI) has studied the retention of knowledge and skills for over three decades, and has identified instructional strategies to enhance the retention of skills (Wisher, Sabol, & Ellis, 1999). Recently, Moses (2000) has identified training challenges associated with the new generation of digital systems to include:

- Frequent upgrades in digital system hardware and software limit learning of skills to mastery levels and place great demands on refresher training.
- The volume of ambiguous data, along with smaller operational units and novel situations, require methods for training junior and mid-level soldiers to be flexible and adaptive.
- Training time and resource limitations demand that training of digital procedures and skills including back-up and work-around skills -- are integrated into training of tactics, techniques, and procedures.
- Future operations call for widely dispersed soldiers linked through electronic networks to perform as digital teams with new training demands.

## *Cognitive Principles for Training*

Cognitive psychology learning paradigms include learning theories which consider the nature of individual learning as well as how knowledge is constructed in social situations, and include behaviorism, cognitivism, and constructivism. For behaviorism, learning reflects a new behavioral pattern being repeated until it becomes automatic, while cognitivism views learning in terms of the thought process behind the behavior. Constructivism is distinguished by its premise that learners construct their own perspective of the world, based on individual experiences and schema (Wilhelmsen, Asmul, & Meistad, 1998). The review of theories of learning can provide the basis for identifying theory-driven technology-based approaches to meeting training requirements (Lajoie, 2000). One of the great contributions of cognitive psychology has been in providing a typology of different kinds of knowledge that are used in the conduct of intelligent activity (Samarapungavan, Beishuizen, Brazier, & Sanders, 1993). Taxonomies might be identified for separating digital C4I tasks into categories of like tasks for the selective application of training techniques. Following a cognitive psychology approach, training development for digital C4I tasks would begin with an assessment of the cognitive demands of the specific tasks to be trained. Instructional techniques tailored to meet these task demands would then be identified.

With the rapid advance of computer hardware and software capabilities, a great deal of effort is being devoted to the development of CIT to replace or supplement the traditional exposition-application classroom lecture education, and to provide an economical source of sustainment training. Researchers caution us, however, that the training potential of emerging technologies stems not simply from technologically advanced capabilities, but from the ability to vary instructional methods and media systematically according to the cognitive demands of learning tasks (Hooper & Hannafin, 1991). While advances in computer technology have led to the large scale introduction of multimedia digital skills training applications, examples of recent digital C4I training systems, even those delivered over the Internet, suggest that much of training has not advanced far beyond computerized "page-turner" training techniques (Program Manager FBCB2, 2000).

Recent research examining staff training methods for future forces has recommended the incorporation of instructional principles drawn from cognitive psychology in training design and the expanded application of embedded training to the battalion and brigade staff (Deatz, Greene, Holden, Throne, & Lickteig, 2000). Here, the authors have called for the incorporation of cognitive training techniques such as advance organizers, part-task training, deliberate practice, and context-based training to support future staff training needs.

## *Automated Performance Assessment and Feedback*

While the introduction of digital systems may have led to increased training demands, these systems also offer great potential as hosts for training program features to address training needs, particularly with regard to capabilities for automated performance assessment and performance feedback. One goal of the present research was to identify opportunities to incorporate automated performance and assessment into digital C4I system training. Examples

of levels of digital C4I task performance criteria have been identified (Sanders, 1999) that could be used to assess operator procedural task training program change requirements. The prototype Armor Captains' Career Course - Distance Learning (AC3-DL) program (U.S. Army Armor School, 2000a) provides an example of how training program techniques based on cognitive psychology can be incorporated into computer-based distance learning. While the AC3-DL training does not address digital procedural skills, it does provide examples of techniques for incorporating automated and instructor-assisted performance assessment and feedback in asynchronous self-paced training, and synchronous collective training in virtual and constructive environments provided as distance learning over the Internet (U.S. Army Armor School, 2000b).

### *Research Hypotheses*

Having addressed the need for incorporating cognitive psychology principles in training design, and the importance of considering automated performance assessment and feedback in training development, several research hypotheses can be identified for the present research. The success of the research effort reported in this document can be measured in part by addressing each of the following research hypotheses:

1. A taxonomy can be identified for separating digital C4I tasks into categories of like tasks for the selective application of training techniques.
2. Cognitive principles for optimizing the acquisition, retention, and transfer of skill can be translated into digital C4I system prototype training techniques.
3. Automated performance assessment and feedback training program techniques can be identified that support the acquisition, retention, and transfer of operator skills.

### *Research Approach*

The research effort began with the identification of a representative digital C4I system that could be used to design, develop, and demonstrate prototype training techniques. Three linked workstations running the C4I software were set up to examine tasks in detail. A literature review was initiated to identify key cognitive psychology principles that support the acquisition, retention, and transfer of skills. The literature review results were summarized in table form and used in discussions with subject matter experts to identify specific techniques that could be incorporated into prototype digital C4I training. Prototype training modules for four digital C4I tasks were produced, and opportunities to incorporate automated performance assessment and feedback were identified.

### *Report Organization*

This report first describes the digital C4I system selected for training techniques development. Next, the approach used for selecting representative C4I tasks is presented. A description of key cognitive principles and techniques supporting training design follows. Cognitive principles and training techniques are presented in table form, and annotated to indicate ways in which the techniques could be incorporated into C4I system prototype task training. Examples of prototype training which demonstrate the integration of the cognitive

psychology principles are presented, followed by a discussion of the present research effort and future directions.

### Selecting Tasks for Training Techniques Identification

#### *An Exemplar Digital Information System*

The FBCB2 system was selected for the purpose of identifying and documenting cognitive training techniques applicable to a representative Army digital information system. The FBCB2 is a digital battle command information system for leaders and soldiers within the mounted brigade across all battlefield operating systems (U.S. Army Armor Center, 1997). While the FBCB2 was selected for the purpose of identifying cognitive training techniques, it must be remembered that the goal of the research is to identify theory-based training techniques generalizable beyond specific FBCB2 training applications.

The FBCB2 is a software-based system implemented in desktop computers and tactical computer units. The FBCB2 operator navigates through software menu options and enters data to create overlays and pre-formatted reports using multifunction keys, screen menus, a multifunction keypad, and a computer keyboard (U.S. Army Armor Center, 1997) (see Figure 1). For the present research, software version 3.3.2. was used. A 40 hour FBCB2 Operator Training class is provided for both officers and enlisted personnel by a New Equipment Training Team (NETT) using desktop computers and FBCB2 software. For example, the class would include a 40 hour block of instruction on FBCB2 mission planning steps required to create and send a digital map overlay showing battlefield graphics and control measures. A three day Leaders Course is provided to give instruction on how to employ FBCB2 features such as filters to manage information. The FBCB2 software incorporates an embedded tutorial which consists of an illustrated version of the Program of Instruction (POI) text. After the classroom training, personnel are expected to maintain proficiency through hands-on practice at the unit.

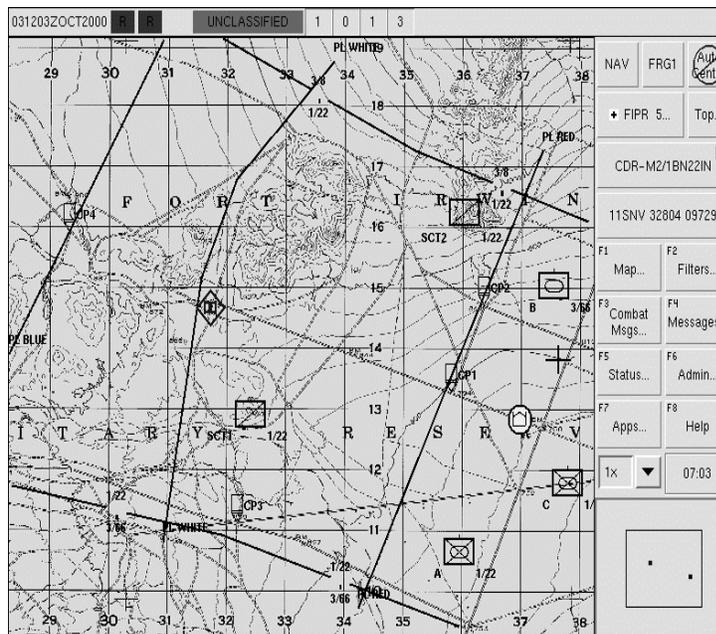


Figure 1. FBCB2 Screen showing map area and navigation menu.

### *Task Knowledge and Training Method Taxonomy*

For the present research, it was desired to identify cognitive task characteristics related to specific training approaches that could be used as a taxonomy for classifying tasks. Such a taxonomy can facilitate the generalization of training research findings beyond the specific tasks examined in the research. A key contribution of cognitive psychology is that it identifies typologies of different kinds of knowledge used in the conduct of intelligent activity. A common distinction is to separate knowledge into four types: (1) declarative knowledge -- domain-specific knowledge of facts typically embodied in statements of the form "I know that...", (2) procedural knowledge -- knowledge of procedures as expressed in the ability to carry out the procedures and embodied in statements of the form -- "I know how to ...," (3) content knowledge or knowledge of a specific subject matter, and (4) metacognitive knowledge which is knowledge about general principles of thinking and reasoning that is applicable across specific content domains (Samarapungavan et al., 1993).

Having identified types of knowledge that support the tasks, the next step is to identify types of training that support each type of knowledge. One common distinction is to separate learning into two types, "accretion" and "restructuring." Accretion refers to learning by the gradual accumulation of additional units of knowledge, where the new knowledge does not require the reorganization of existing knowledge. Accretion is associated with learning tasks that require discriminations and generalization, and might support the acquisition of content knowledge, and procedural knowledge. In contrast, restructuring refers to learning where the acquisition of new knowledge requires reorganization or replacement of existing knowledge. Restructuring learning involves the creation of conceptual conflict and the resolution of this conflict, and might support the acquisition of declarative knowledge, and metacognitive knowledge (Samarapungavan et al., 1993). Table 1 presents a simple task classification taxonomy based on these principles.

Table 1

Taxonomy of Task Knowledge Type and Training Approach

Task Knowledge	Content	Procedural	Declarative	Metacognitive
Training Approach	Accretion	Accretion	Restructuring	Restructuring

### *Task Analysis*

It was desired to obtain a sample of FBCB2 tasks that reflected different kinds of knowledge requirements (e.g., content, procedural, declarative, metacognitive) to identify where training techniques might support different types of tasks. Task knowledge requirements were assessed through discussions with experienced Army digital system instructors who had hands-on experience with the FBCB2 system, and a detailed knowledge of the FBCB2 Operators Course POI. The author also performed tasks at an FBCB2 work station to assess the cognitive

requirements. The “Case Study” approach outlined by Cooke (1994) was used to identify the cognitive demands of specific FBCB2 tasks, to include reports, overlays, a collection of information management tasks, and orders preparation. Based on this review, four FBCB2 tasks were selected to represent different kinds of task knowledge requirements.

### *FBCB2 Tasks Selected*

*Reports.* The "Create and Send Reports" task was selected as an individual task requiring procedural skills. The reports task represents one of the most basic capabilities of digital C4I systems, and should be a common task for many current and future systems. The task is linear, requiring that the FBCB2 operator navigate menus selecting options to input data into a preformatted report template. The instructional goal is to train procedural skills required to navigate FBCB2 menus, and select data input options. Learning should primarily involve the process of knowledge accretion. For the specific reports task being trained in the present research, no subject matter knowledge was required.

*Overlays.* The "Create and Send Overlays" task was selected as an individual task requiring procedural skills. The overlays task also represents one of the most basic capabilities of digital C4I systems, and should be a common task for many current and future systems. The task is flexible requiring that the operator navigate menus selecting and performing multiple graphics subroutines in no specific sequence to place graphics on a map display. Task flexibility in selecting and performing graphic subroutines makes this a more complex task than the Reports task. The instructional goal was to train procedural skills required to navigate FBCB2 menus, and select and perform subroutines. Learning should primarily involve the process of knowledge accretion. For the specific overlay task selected, no subject matter knowledge was required for task completion.

*Information Management.* The "Information Management" task was selected as an individual task, requiring both content and declarative knowledge to apply rules, and review, synthesize, and redirect information. The task involves basic FBCB2 set-up procedures such as adjusting information filters, and setting up the list of stations to include the communications net. Learning to perform the task to proficiency could require knowledge restructuring. This task was chosen to expand beyond simple procedural skills training, to train the application of digital information system capabilities to a complex task.

*Orders Preparation.* The “Orders Preparation” task was selected as a collective task that requires both procedural and declarative knowledge skills. Task performance requires the application of declarative knowledge rules, staff officer content knowledge, and the ability to synthesize and integrate information to perform a realistic task. Learning to perform the task to proficiency might require knowledge restructuring. This task was selected to expand beyond the individual procedural skill application task (i.e., Information Management) to address issues of collective/collaborative work mediated via a digital information system.

## Learning Principles for Training Design

### *Introduction*

Researchers have suggested that theories of learning provide instructional designers with verified instructional strategies and techniques for facilitating learning as well as a foundation for intelligent strategy selection (Ertmer & Newby, 1993). A central goal of the present research was to analyze how the principles held by different theories of learning might be translated into training techniques supporting digital skills training. Principles associated with three theoretical positions on learning (behaviorist, cognitive, and constructivist) were first identified. Next, interviews and a hands-on review of FBCB2 tasks were conducted to identify training techniques derived from learning principles that could be implemented in digital C4I system training.

The three theoretical perspectives each treat learning from differing viewpoints, with different goals and approaches for training design. Behaviorist theory is based on behavioral changes, where learning reflects a new behavioral pattern being repeated until it becomes automatic. In contrast, cognitivism is based on the thought process behind the behavior. Changes in behavior are observed, but only as an indicator to what is going on in the learner's mind. Constructivism is based on the premise that learners construct their own perspective of the world, based on individual experiences and schema. Here, learning focuses on preparing the learner to problem solve in ambiguous situations (Wilhelmsen, Asmul & Meistad, 1998).

In presenting learning principles and related training techniques, information was summarized in tables. This format was adopted to facilitate discussions and transfer theoretical principles to the training design team developing prototype FBCB2 training modules. The tabled information was used in checklist fashion to identify opportunities for incorporating psychological principles into the design of training techniques for prototype training modules.

### *Behaviorist Learning Principles and Techniques*

*Behaviorist theory overview.* Behaviorists typically view knowledge as passive, largely automatic responses to external factors in the environment. Learning amounts to stimulus-response pairings, and mastery of a complex task (such as the sequence of steps required to perform a procedure) involves the development of a chain or repertoire of such connections (Van Patten, Chao, & Reigeluth, 1986). No attempt is made to determine the structure of a student's knowledge or to assess which mental processes are in use. Rather than attempting to estimate knowledge, the behaviorists focus on observable and measurable performance outcomes. Forgetting is attributed to the non-use of a response over time. Behaviorist training strategies center around building and strengthening stimulus-response associations through the use of instructional cues, practice, and reinforcement (Ertmer & Newby, 1993).

*Types of learning best explained by behaviorist theory.* The behaviorist approach has been effective for tasks that involve making discriminations (recalling facts), generalizations (defining and illustrating concepts), associations (applying explanations), and chaining (automatically performing a specified procedure) (Ertmer & Newby, 1993).

*Training design principles.* Behaviorism was used as the basis for designing many of the early audio-visual materials and teaching strategies, such as Skinner’s teaching machines and programmed texts. More recently these principles have been used in computer-assisted instruction and mastery learning. Training development requires the separation of tasks into sequential elements, and that a method be provided for the pre-assessment of students to determine where instruction should begin. Table 2 presents behaviorist principles identified by Ertmer and Newby (1993), annotated with training techniques that could be implemented in the FBCB2 prototype training modules.

Table 2

Behaviorist Principles and Related Training Techniques

Behaviorist Principles	Training Techniques
1. Observable & measurable outcomes.	Behavioral objectives, task analysis, criterion referenced assessment. - FBCB2 task analysis identifies required task performance sequencing. - Self-assessment: Student compares FBCB2 Overlay produced to a standard provided.
2. Pre-assessment of students to determine where instruction should begin.	Learner analysis. - Identify previous FBCB2 training, present "What's new" summary of change information. - Identify staff position, direct student to FBCB2 information tailored to this position.
3. Emphasis on mastering early steps before progressing to more complex levels of performance.	Sequencing of instructional presentation, mastery learning. - Master FBCB2 procedural tasks before moving to Practical Exercises.
4. Use of reinforcement to impact performance.	Tangible rewards, informative feedback. - Screen changes with correct inputs. - Successful completion viewed as reward.
5. Use of demonstration, cues, shaping and deliberate practice to ensure a strong stimulus-response association.	Simple to complex sequencing of practice, use of prompts. - Context-sensitive "Help" box in FBCB2 procedural task training, "Hints" box in applied Practical Exercise, but less frequent (fading) as lesson progresses.

*Behaviorist theory training design implications.* The behaviorist approach should be highly effective in training basic procedural tasks to proficiency in the shortest period of time through massed practice. However, the behaviorist approach does not support the acquisition of declarative knowledge of the task, and thus does not support long-term retention. The behaviorist practice of teaching a fixed set of stimulus-response pairings does not provide an opportunity to explore alternative approaches to task accomplishment, and to learn error recovery steps, which could support the transfer of skills to changing task demands. The

behaviorist approach should be successful in quickly providing the learner with one way to accomplish a task, but it will be necessary for the learner to have an opportunity to explore alternative options for task accomplishment (break the procedure into chunks of similar steps, identify underlying principles of task organization, translate this understanding of principles into declarative knowledge), to achieve long-term skill retention, and transferability.

A potential weakness of the behaviorist training approach is that it may not be an efficient means of training complex tasks. In particular, for many digital information system tasks there is more than one way to accomplish the task. It would be inefficient to teach each variation of a task (for example 10 similar reports) as a unique task involving the chaining together of action steps to complete a procedure. Instead, training should prepare the soldier with flexible skills that can adapt easily to changing task demands as equipment and software updates are introduced. The stimulus and response approach of behaviorism does not support this goal of flexibility.

*Automated performance assessment and feedback.* Part of the appeal of the behaviorist approach is that the assessment of stimulus-response pairings lends itself to automated assessment and feedback. With respect to training the sequence of steps required to accomplish a procedural task, the behaviorist approach can support a simple approach to automated performance assessment and feedback. Applying behaviorist theory to FBCB2 procedural task training, the selection of each menu item in a sequence of steps can be assessed, and immediately followed with feedback. Successful menu item selection results in a change in the interface (data values appear, or next menu item comes up). Failure to select the correct menu item results in a non-response from the interface, or can result in an information box appearing to indicate that the response is incorrect.

### *Cognitive Learning Principles and Techniques*

*Cognitive theory overview.* Cognitive scientists seek to identify the mental functions and processes that underlie behavior. In contrast to behaviorism's focus on observable behavioral change brought about through stimulus-response pairings, cognitive theories emphasize making knowledge meaningful and helping learners organize and relate new information to existing knowledge in memory (Samarapungavan et al., 1993). Cognitive theories focus on the conceptualization of students' learning processes and address the issues of how information is received, organized, stored, and retrieved by the mind. Designers use techniques such as advance organizers, analogies, hierarchical relationships, and matrices to provide an organization and structure to information that is intended to help learners relate new information to prior knowledge (West, Farmer, & Wolff, 1991). A key feature of cognitive theories is that the learner is viewed as an active participant in the learning process, and training design seeks to facilitate the student's active involvement.

One way in which learners can be actively involved in their own learning is by adopting a preferred learning strategy. While cognitive theory identifies principles for how information is received, organized, stored, and retrieved, the individual learner is not necessarily aware of how these activities occur during learning. In contrast, the term "learning strategies" is used to refer to a set of naturally occurring mental strategies, or ways of organizing information, that people

employ while learning. The learner might select one learning strategy over another based on their previous experience with the material to be learned, or based on their personal goals for learning (e.g., task familiarization, task mastery, short, or long-term retention). Offering multiple learning strategies within a training program allows students to become self-regulating and actively involved in learning so that they can better achieve their learning goals (Purdie & Hattie, 1996). Three learning strategies were considered as modes for interacting with lesson material in the prototype FBCB2 training modules interface: (1) demonstration mode (a movie-style presentation of task performance), (2) teacher mode (training system models correct behavior and guides student through each step of the task), and (3) concurrent mode (student engages in self-paced training using the operational FBCB2 software while being able to access support from the training system on demand).

Incorporating these three modes of learning might provide a means of individualizing training delivery to the needs of the learner, whether it is for initial skill acquisition, or a quick review of previously learned materials as sustainment training. Simon and Werner (1996) found the behavior modeling strategy to be superior to self-paced training and demonstration modes for both declarative and procedural knowledge associated with a basic course teaching computer skills. However, different knowledge requirements (e.g., initial training, sustainment, and transitioning to updated software) might call for different learning strategies.

*Types of learning best explained by cognitive theory.* Cognitive theories focus on the conceptualization of students' learning processes and address the issues of how information is received, organized, stored, and retrieved by the mind. This focus supports training for more complex forms of learning associated with individual and collective reasoning, problem-solving, and information processing. Table 3 presents cognitive theory principles identified by Ertmer and Newby (1993), and annotated with training techniques that could be implemented in FBCB2 prototype training modules.

*Structuring information for training delivery.* Cognitive theory places a great emphasis on structuring, organizing, and sequencing information to facilitate optimal processing. Table 4 presents learning strategies identified by West et al. (1991) that can be used to accomplish these goals, and which can be incorporated in training design to facilitate learning. Training techniques associated with specific learning strategies were identified during the present research effort and are annotated in Table 4.

Table 3

Cognitive Principles and Related Training Techniques

Cognitive Principles	Training Techniques
<p>1. Emphasis on the active involvement of the learner in the learning process, to include learner control of training delivery method.</p>	<p>Learner selected training delivery modes:</p> <ol style="list-style-type: none"> <li>1. Demonstration Mode: Demonstrates correct sequence of task steps to student.                             <ul style="list-style-type: none"> <li>- FBCB2 task step performance video recorded and presented in movie-style fashion.</li> </ul> </li> <li>2. Teacher Mode: Models behavior, and guides student through required task steps.                             <ul style="list-style-type: none"> <li>- Training simulates FBCB2 software and guides student through correct steps to complete a task. Can bring up informative feedback text boxes for incorrect responses.</li> </ul> </li> <li>3. Concurrent Mode: Student engages in task performance in the actual software environment with access to training "Help" features.                             <ul style="list-style-type: none"> <li>- Desirable, but not available as FBCB2 does not allow "Training Shell" software application to run in parallel with FBCB2 software.</li> </ul> </li> </ol>
<p>2. Use of hierarchical analyses to identify and illustrate prerequisite relationships.</p>	<p>Cognitive task analysis procedures.</p> <ul style="list-style-type: none"> <li>- Training developers perform a variety of FBCB2 tasks, analyze these protocols to identify prerequisite relationships, and resulting order for instructional content presentation.</li> </ul>
<p>3. Emphasis on structuring, organizing, and sequencing information to facilitate optimal processing.</p>	<p>Use of cognitive strategies such as outlining, summaries, synthesizers, advance organizers.</p> <ul style="list-style-type: none"> <li>- Instructional design template incorporates advance organizers, lesson summaries.</li> <li>- FBCB2 instructional design incorporates numerous cognitive strategies identified by West et al. (1991) and described in detail in Table 4.</li> </ul>
<p>4. Creation of learning environments that allow and encourage students to make connections with previously learned material.</p>	<p>Recall of prerequisite skills: Use of relevant examples, analogies.</p> <ul style="list-style-type: none"> <li>- FBCB2 training could link to web-based course subject matter knowledge.</li> </ul>

Table 4

Cognitive Strategies and Related Training Techniques

Cognitive Strategies	Training Techniques
1. Chunking: Rational ordering, classifying, or arranging of complex arrays preparatory to deeper processing.	Linear ordering, classification taxonomies. - FBCB2 task content chunked into categories of similar task steps for training (e.g., Overlay one-point and two-point graphics grouped).
2. Frames 1: A matrix, grid, or framework for representing knowledge organized by a spatial strategy. Facilitates comparisons and contrasts. Presents holistic cognitive structure for material.	Visual display of substantial amounts of information. - A summary of the chunks and supporting elements required for task performance, along with a visual display of the end product.
3. Frames 2: A matrix organized by some lawful principle, allows use of logic or inference to fill in missing information.	Information Matrix: Could show commonality between similar tasks, shared steps. - No example identified for FBCB2 training.
4. Concept Map: Graphics reveal the structural pattern in the material, provide the "big picture." Aids the recall of detail. Computers good in allowing flexible presentation of material and relationships.	Extract concepts and relationships from text or lecture and plot these visually. - FBCB2 training graphics can present the underlying logic for the software menu structure.
5. Advance Organizer: Presented prior to new material. A brief transition statement identifying connections between prior learning and new material.	Connect new material to student prior knowledge. - FBCB2 Training can provide introductory text bullets identifying key points and organizing concepts of material to be trained.
6. Metaphor: Sensitizes student to similarities between something known and something new. Helps learner transfer prior knowledge to another topic. Helps sensitize learner to similarities across knowledge arrays.	Metaphor, rich in imagery and figurative language and highly generalizable, connects current learning to previous, a bridging strategy. - FBCB2 training can include a graphic depicting a tactical operations center (TOC) that provides access to information needed for tasks.
7. Rehearsal: Activities to keep material active in consciousness to support transition into short-term memory. Supports deeper processing for long-term recall. Gets learner actively, intellectually engaged in processing information, not just passively exposed to information.	Repetition, questioning, answering, restating, clarifying, reviewing, summarizing, note taking. - FBCB2 training can present a quiz or information summary in the body of training, video demonstrations of task performance, and access to self-paced practical exercises.
8. Imagery: Cognitive strategy that aids recall. Mental pictures learner forms to aid recall. A key way of storing information in the mind, images can hold large amounts of information and great detail.	Mental visualization of concrete information, objects, events, arrays. - Illustration graphically depicting FBCB2 digital menu architecture associated with different tasks, can be presented to aid menu structure recall.
9. Mnemonics: Artificial aids to memory used with material low in structure until meaningful mental structures developed.	Keywords, chains, method of loci visualization, single use coding (e.g., Size of unit, Activity, Location, Unit, Time, Equipment [SALUTE]). - No mnemonic devices identified for FBCB2.

*Cognitive theory training design implications.* Cognitive theory suggests that knowledge is stored as organized mental representations and that training can be designed to incorporate techniques that facilitate the organization of new information presented in training. As an example, using cognitive principles the training designer can introduce an organizing framework, and knowledge goals, for the student to use in making sense of information that follows. The training designer can make declarative knowledge of underlying task concepts one of the goals of training, and introduce assessment tools such as quizzes to determine if the learner has gained this concept knowledge. Likewise, informative feedback can be developed to reinforce the concepts being taught.

The cognitive approach is associated with deeper (declarative) knowledge of a task, which is associated with long-term retention. Teaching underlying principles for tasks should also yield more flexible knowledge that is more adaptable to changing task demands as equipment, hardware, and software updates are introduced. The cognitive approach may require more training time to bring a student to basic procedural proficiency on tasks, but can yield enhanced skill retention (Druckman & Bjork, 1991). Preparing materials for presentation using cognitive approaches could be more difficult than when using a behaviorist approach because the instructional designer needs to conduct detailed task analyses with experts to understand the underlying cognitive demands of the task, and so identify the mental representations to be taught.

*Automated performance assessment and feedback.* With regard to performance assessment and feedback, the behaviorist uses feedback as “reinforcement” to modify behavior in the desired direction while cognitivists use feedback as “knowledge of results” to guide and support accurate mental connections. Performance assessment can include basic measures of successful task completion, however, the cognitive approach also requires that the instructional designer incorporate measures of whether the student has learned the concepts underlying task performance. The cognitive approach lends itself to automated performance assessment and feedback through the use of quizzes and tests, accompanied with corrective explanatory feedback. For complex tasks such as map overlay construction, students could be presented with the "expert solution" at various stages of the task, allowing them to self-assess their actions.

### *Constructivist Learning Principles and Techniques*

*Constructivist theory overview.* Constructivist theory views learning as an active process in which learners construct new ideas or concepts based upon their current and past knowledge. The learners select and transform information, and construct hypotheses to discover principles by themselves (Bruner, 1966). Constructivist theories emphasize the importance of exploration and discovery on the part of each learner in the learning process. They also view the collaborative efforts of groups of learners as sources of learning.

An important theme in constructivist theory is that learning is most effective when it takes place within a realistic task context. Researchers suggest that formal instruction in the "school house" can lead to a "divorce of knowledge and skills from their applications in the real world context" (Samarapungavan et al., 1993). Situated learning is a general theory of knowledge acquisition which proposes that learning, as it normally occurs, is a function of the activity, context, and culture in which it occurs (i.e., it is situated). Employing the "cognitive

apprenticeship" instructional approach, students might model skills demonstrated by an expert tutor or coach in a realistic setting. The sequence of tutorial feedback in coaching would start with a high degree of external support or "scaffolding" for beginning learners and move to a gradual reduction of support as learning progresses, an instructional technique referred to as "fading" (Samarapungavan et al., 1993).

*Types of learning best explained by constructivist theory.* The primary goal of constructivism is to foster problem-solving and conceptual development (Reigeluth, 1999). The constructivist approach appears best suited for ill-defined or ill-structured domains of knowledge and thus might support the training needs of the digital C4I task environment characterized by a fluctuating mixture of both digital and conventional message traffic. Looking at one example of learning in the military context, Lussier, Ross, and Mayes (2000) have examined commander and staff tasks. They found that performance problems were often not due to a lack of tactical knowledge, instead problems arose from difficulties in applying this knowledge in complex situations which can overwhelm a person's ability to attend to events and to think through decisions under stress. These authors have developed training to facilitate "adaptive thinking" in response to unanticipated circumstances; this training combines the constructivist principles of coaching and scaffolding with the behaviorist technique of deliberate practice. The deliberate practice focuses on areas of weakness to create automatic habits. These automatic habits, which in the present instance could include tasks associated with exchanging a mixture of conventional voice radio and digital C4I information, could serve to reduce the requirement for attention resources; thereby freeing the commander and staff to focus on the content, and not the format of the information being presented.

*Constructivist theory training concepts and design principles.* While both behaviorist and cognitive learning theories advocate the rational ordering, classifying, or arranging (i.e., chunking) of information to be presented in training, some advocates of constructivist learning approaches contend that this blocking of material by category may aid initial acquisition, but may not yield optimal retention. Healy and Bourne (2000) suggests that the retention of knowledge is enhanced when the learner is required to first process the information as it occurs in a realistic task context. In their view it is the student and not the instructor who needs to do the processing and blocking of material into personally meaningful categories. It should be noted that constructivist theory calls for the creation of realistic "learning environments," and that recent advances in computer technology have greatly enhanced our ability to simulate individual and collective task environments. Table 5 presents constructivist theory principles derived from the preceding discussion. The principles are annotated with training techniques that could be implemented in a simulated C4I task environment.

Table 5

Constructivist Principles and Related Training Techniques

Constructivist Principles	Training Techniques
1. Context-based training/Situated cognition. Knowledge needs to be presented in an authentic context. Problem should be ill-defined, ill-structured.	Anchoring learning in meaningful contexts. - C4I Learning Environment: Simulated TOC and realistic tasks performed collectively by groups of students.
2. An emphasis on learner control and ability to manipulate information.	Actively using what is learned. - C4I Learning Environment: Students role-play commander and staff and use generic map and text tools to exchange information.
3. Provide multiple modes of representation for instructional content.	Provide student with methods for examining material from multiple perspectives. - C4I Learning Environment: Provide information as radio voice message traffic, digital text messages, simulated faxes, information from maps, doctrinal documents, and plans. Rotate assigned roles of students.
4. Promote case based reasoning (CBR).	Provide related cases or worked examples to enable CBR and cognitive flexibility. - C4I Learning Environment: Incorporate realistic vignettes that require unique solutions.
5. Assessment focused on transfer of knowledge and skills.	Present problems and situations that differ from the conditions of initial instruction. - C4I Learning Environment: Include novel vignettes to assess transfer to similar but not identical situations.
6. Coaching.	Expertise comes from good coaching. - C4I Learning Environment: Incorporate Adaptive Thinking training principles, with deliberate practice managing changing digital/conventional unit communications data mix, evaluation and synthesis tasks.
7. Use conflicting perspectives, and cognitive dissonance, to force students to rethink their assumptions.	Put student in an immersive problem-solving context from the beginning of training. - C4I Learning Environment: Collective task performance and peer assessment should generate rethinking of assumptions, and restructuring of decision making knowledge.
8. Learning requires social interaction and collaboration between learners, testing their own understanding against that of others (social negotiation of meaning).	Training should include collective scenario-based tasks. - C4I Learning Environment: Leverage peer assessment and peer tutoring.

Table Continues

Table 5 (Continued)

<p>9. Prerequisite knowledge is provided within the context of higher order learning and application through "scaffolding" or the ability to go back to previous information for review.</p>	<p>Learning environment allows student to review previous information.          - C4I Learning Environment: Students could access previous doctrinal information either through Small Group Instructor (SGI), or through a supporting information base via the AC3-DL web site.</p>
<p>10. Cognitive Apprenticeship. Students should model skills demonstrated by an expert tutor or coach.</p>	<p>Students should model skills demonstrated by an expert tutor or coach.          - C4I Learning Environment: SGI serves as expert and coach.</p>
<p>11. Scaffolding and Fading. Provide cognitive tools and coaching that scaffold required skills, including problem representation, knowledge-modeling, performance-support, and information-gathering tools. Gradual fading of support as learning progresses.</p>	<p>Scaffolding starts with a high degree of external support which gradually fades.          - C4I Learning Environment: SGI must assess students' strengths, and provide support scaffolding as required.</p>

*Constructivist theory training design implications.* Constructivist theory proposes that knowledge is individually constructed and socially co-constructed by learners based on their interpretations of experiences in the world. Following this principle, training should consist of experiences in realistic task environments that facilitate knowledge construction (Jonassen, 1999). Constructivist theory appears to lend itself to ill-defined tasks, and seeks to address higher level cognitive tasks, particularly those involving collective task performance. Thus it might have great utility in identifying training requirements for battalion commander and staff collective C4I tasks. A disadvantage of the constructivist approach is that it can be expensive to create realistic learning environments in which learners can practice tasks and derive a personal sense of their organization. Also, it is not known whether knowledge resulting from the structuring of situational factors might be highly idiosyncratic, and not generalizable beyond the personal dynamics of the particular group members in the learning environment.

*Automated performance assessment and feedback.* Lower structure characteristic of constructivist environments could result in less consistency in the processes used to perform a task. To address this problem, structure might be incorporated following the "Think Like A Commander" instructional approach (Lussier et al., 2000). Using this approach probe questions might be inserted into training to identify learning on specific themes, and a series of sub-tasks might be developed to provide multiple opportunities for self-assessment and coaching. While automated performance assessment and feedback is a goal of CIT, the constructivist approach does not appear to lend itself to automation as easily as behaviorist and cognitive approaches. In particular, individual contributions to collective performance are difficult to assess. Currently the tasks of performance assessment and feedback would likely be performed by an instructor or coach.

## *Summary of Learning Principles and Training Techniques*

The present review of behaviorist, cognitive, and constructivist theories and training techniques provides evidence that the learning principles held by the different perspectives can facilitate the identification of training techniques supporting digital skills training. While nearly all of the training principles associated with behaviorist and cognitive learning theory might be implemented using CIT technology, it appears that most of the training techniques associated with constructivist theory could not be applied using a stand-alone CIT, and would require instead a virtual representation of the collective task environment. Specifically, the review of constructivist theory and techniques suggests that a training environment is needed that would support learner control and the ability to manipulate information. This would provide an environment for social interaction, social negotiation, and collaboration. These processes represent important training needs for collective commander and battle staff planning and decision making tasks.

Incorporation of cognitivist theory training techniques into C4I training design should facilitate skill acquisition, retention, and transfer. The cognitivist approach emphasizes a deeper understanding of the concepts underlying task performance, and might actually result in a longer time requirement for soldiers to demonstrate skill acquisition. However, the deeper processing of task concepts during the acquisition phase is associated with greater retention of the acquired skills (Druckman & Bjork, 1991). Providing alternative self-selected modes of learning, particularly the ability to interact with the actual system software, could enhance skill transfer to changing tasks. Training techniques that provide the learner with more experience in non-linear task performance, and error recovery, should enhance the transfer of the originally acquired skills to FBCB2 tasks that change due to software updates. With regard to skill retention and transfer, it is not known whether knowledge resulting from constructivist learning environments might be highly idiosyncratic, and not generalizable beyond the personal dynamics of the particular group members in the learning environment.

## *Outline for a Training Module Structure*

The present research effort sought to identify ways in which cognitive psychology could be incorporated into the overall training module design as well as providing recommendations for specific screens. As part of this research an outline for a training module structure was developed to support the implementation of the cognitive training techniques presented in this report (see Appendix B). This outline describes a series of eleven template screens designed to accomplish essential training program functions for CIT modules.

## Prototype Training Modules

The present research provided guidance and support to a parallel contract effort to design, develop, and demonstrate prototype training modules incorporating cognitive training techniques for a representative Army digital C4I system (Deatz & Cobb, [in preparation]). The cognitive psychology principles, initial set of training techniques, and outline for a training module structure identified in the present research were provided to the contract team to support their efforts. PowerPoint graphics software was used by the contractor team to demonstrate the

incorporation of cognitive theory training principles through the use of FBCB2 screen captures, text boxes, motion video, and simple navigation tools. The software supports what is referred to as "page-turning architecture" which basically presents the learner with an action requirement or question, the response to which will call up another page of information (Schank, 1990). Four FBCB2 tasks were selected by the contractor team for training module development: Reports, Overlays, Information Management, and Orders Preparation. Figure 2 presents an example training screen developed by Deatz and Cobb (in preparation) showing training information and navigation features surrounding an actual FBCB2 screen capture illustration. By following the guidance provided by the training program, a student can practice pulling down menu options, activating features, and entering data to complete the steps required to create and send an FBCB2 Spot Report.

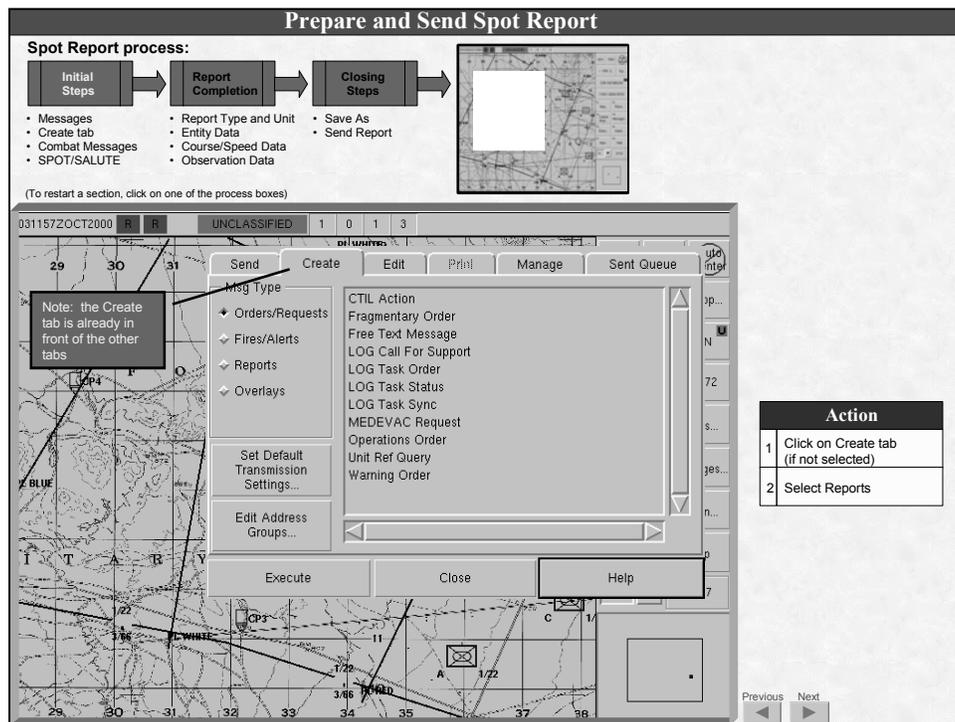


Figure 2. Prototype FBCB2 training screen. Illustration from Deatz and Cobb (in preparation).

The training material screen shown in Figure 2 serves to demonstrate the implementation of several cognitive training techniques that were identified in the present research. The screen provides an information field at the top left hand side of the screen that provides the student with a Concept Map of the Spot Report task. This map chunks the 40 step task into three sub-tasks and identifies the final product of the task. A "Note" box is illustrated which can be superimposed over the map display along with arrow indicators to focus the student's attention to key aspects of the task. The "Training Points" box provides a text description of the key knowledge that the current screen seeks to convey to the student. The "Action" text box on the right hand side of the screen tells the student what specific action to perform (mouse clicks, data entry) to progress through the steps in the task. The "Action" text box can be removed to allow students to test their knowledge of the task sequence requirements or the information can be

called up by the student by selecting a "Hint" box. A consistent set of "Navigation" buttons are provided at the bottom of the screen so that the student can review previous material or go on to the next material based on their own information needs.

An additional feature that the contractor team integrated into the prototype FBCB2 training module screens is the option that allows a student to select their preferred learning style. The student can elect to enter a "Demonstration" mode of training which starts a short (approximately one minute) video showing the required menu navigation actions and data entry requirements to complete a given task (see Appendix C). Other prototype screen designs demonstrate training features that support student-selected training content review (Appendix D) and subject matter quizzes that provide performance assessment and feedback (Appendix E).

## Summary and Discussion

### *Summary*

The goal of the present research effort was to identify training program techniques based on learning principles that could be incorporated into CIT modules for future digital skills. To accomplish these goals representative FBCB2 tasks were first identified that require a range of cognitive skills, which would likely require alternative training strategies. Second, principles of cognitive theory and their related training techniques were identified that could be incorporated into the prototype FBCB2 training. Examples of training materials from a prototype FBCB2 training program developed in a parallel contract effort by Deatz and Cobb (in preparation) were presented which demonstrate how the cognitive techniques can be implemented to train individual procedural skills.

### *Research Hypotheses*

Results indicate that recent learning principles can be identified and translated into specific training techniques that can enhance digital C4I training. The success of the research effort can be measured by the ability to answer each of the research hypotheses.

*Hypothesis 1.* A taxonomy can be identified for separating digital C4I tasks into categories of like tasks for the selective application of training techniques.

Table 1 identified a simple approach to classifying tasks in terms of their knowledge demands which is a necessary first step in developing training to address the cognitive demands of tasks. The present research has suggested that the individual procedural skill components of the four tasks might best be trained using CIT, where task skills are acquired through a process of accretion, or the gradual accumulation of additional units of knowledge. In contrast, it was suggested that the individual and collective skill components of the Information Management and Orders Preparation tasks which require problem-solving, reasoning, critical thinking, and the active use of knowledge, might best be trained in a virtual learning environment. The virtual learning environment supports the acquisition of skills through a process of restructuring, where learning requires the reorganization or replacement of existing knowledge.

*Hypothesis 2.* Cognitive principles for optimizing the acquisition, retention, and transfer of skills can be translated into digital C4I system training program techniques.

Tables 2 through 4 identify specific cognitive principles for instruction, annotated with specific examples of where these principles can be implemented as CIT techniques for prototype FBCB2 training, and C4I virtual environment training. Examples of training information screens taken from the prototype FBCB2 training modules developed by Deatz and Cobb (in preparation) were provided to illustrate how the cognitive principles have actually been incorporated into individual procedural skills prototype FBCB2 training modules. Table 5 identified specific constructivist techniques that might be incorporated into a virtual learning environment to train collective declarative knowledge. Using constructivist theory techniques, training might be incorporated into the existing AC3-DL Virtual Tactical Operations Center (VTOC) simulation to provide training to address key digital C4I issues such as data ambiguity and load, and coordination of mixed digital and conventional forces. Incorporation of cognitivist theory into C4I training design could have a significant impact on skill acquisition, retention, and transfer when compared to the behaviorist approach as the deeper processing of task concepts during the acquisition phase is associated with greater retention of the acquired skills. It is not known whether knowledge resulting from constructivist learning environments will show retention and generalizability beyond the specific group members in the original learning environment.

*Hypothesis 3.* Automated performance assessment and feedback training program techniques can be designed, developed, and demonstrated for a future digital C4I system to support the acquisition, retention, and transfer of operator skills.

Key performance assessment and feedback requirements associated with each theory of learning were identified and opportunities to employ automated performance assessment and feedback were described. The design of the prototype training modules developed by Deatz and Cobb (in preparation) in parallel with this research demonstrates how feedback can be provided to the learner to indicate whether the correct behavior was executed in terms of navigating menu options. This type of simple feedback would support the needs of a behaviorist approach to training, and can be easily automated. Feedback is immediate when the system fails to provide the anticipated system cues in response to a learner's actions. Instructive feedback is available from "Help" and "Hint" functions when the learner encounters problems. The prototype training modules also illustrate how cognitive aspects of task learning can be assessed, and feedback provided. The "Review" window feature demonstrates how multiple choice questions can be presented to assess whether the learner understands basic concepts underlying task organization. Where the learner does not understand the concept, this information can be provided in an automated text message. For individual procedural skills training using CIT training modules, both behaviorist and cognitivist theories follow the approach of structuring training concepts for presentation, which lends itself to automated scoring of the rules being taught. Constructivist theory appears most appropriate for individual and collective declarative knowledge training, and emphasizes that knowledge is created by the learner within the realistic task and social demands of the task environment. Performance assessment and feedback for constructivist learning in a virtual task environment would require the service an instructor or coach, and might also rely heavily on peer assessment and feedback.

### *Evaluating Training Effectiveness*

The present research represents a logical continuation of previous IVIS research (Sanders, 1999) which showed that soldiers who acquired more declarative knowledge of task procedures during skill acquisition training also displayed greater skill retention after a 30 day retention interval. Similar retention estimates could be obtained by providing FBCB2 operator skills training using the prototype FBCB2 training modules developed by Deatz and Cobb (in preparation), followed by an evaluation of their ability to perform tasks on the operational equipment. The study could include a control group of students who receive classroom FBCB2 training, followed by an assessment of hands-on performance on tasks using the operational equipment. In examining whether the self-paced and cognitively oriented prototype modules provide better training, the role of declarative task knowledge could again be investigated to identify its relationship to long-term skill retention.

### *Future Research Directions*

Future research could investigate whether prototype training modules could be developed for individual and collective C4I skills requiring problem-solving, reasoning, critical thinking, and the active use of knowledge. The present research suggests that these skills might best be trained in a virtual learning environment. The research should investigate whether the collective skills developed in the virtual environment transfer to the real task environment. In particular, the research should examine whether a generic C4I interface could be used, or whether a realistic C4I interface requiring system-specific procedural skills is required to achieve transfer of higher level skills to the real task environment. Results of the research could suggest whether existing low cost virtual training environments could be used to train higher level C4I collective skills common across a number of different communications platforms, or whether an expensive system-specific communications interface is required for skill transfer. Naturally, the first requirement in conducting this research would be to identify the high-level knowledge requirements associated with C4I commander and staff tasks, such as those identified by Moses (2000), to include information ambiguity, information load, information synthesis, and digital/conventional unit integration issues, and then identify cognitive principles and related techniques that support the training of this knowledge.



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## Appendix A

### List of Acronyms

AC3-DL	Armor Captains' Career Course – Distance Learning
AFRU	Armored Forces Research Unit
ARI	U.S. Army Research Institute for the Behavioral and Social Sciences
C4I	Command, Control, Communications, Computers, and Intelligence
C4ISR	Command, Control, Communications, Computers, Intelligence, Surveillance, and Reconnaissance
CBR	case based reasoning
CIT	Computer-Implemented Training
FBC	Future Battlefield Conditions
FBCB2	Force XXI Battle Command Brigade and Below
FUTURETRAIN:	Techniques and Tools for C4ISR (Command, Control, Communications, Computers, Intelligence, Surveillance, and Reconnaissance) Training of Future Brigade Combat Team Commanders and Staffs
IVIS	Inter-Vehicular Information System
MMBL	Mounted Maneuver Battlespace Lab
NETT	New Equipment Training Team
POI	Program of Instruction
SALUTE	Size of unit, Activity, Location, Unit, Time, Equipment
SGI	Small Group Instructor
TOC	tactical operations center
USAARMS	U.S. Army Armor School
VTOC	Virtual Tactical Operations Center

## Appendix B

### Outline of Screens for Essential Training Program Functions

A series of eleven template screens were identified for potential development that would demonstrate the integration of cognitive principles into the design of FBCB2 training.

Screen 1: Demographics. This screen demonstrates how we can use information about what the student knows to adapt training to individual training needs:

1. Data Capture: Student ID #.
2. Data Capture: Experience with previous versions.
3. Data Capture: Other.

Screen 2: Select an instruction mode. This screen demonstrates a technique for adapting to different student learning styles:

1. Demonstration.
2. Teacher.
3. Concurrent .

Screen 3: Select module for study. This screen demonstrates how we can let the student tailor instruction to his needs:

1. Information management.
2. Reports.
3. Orders.
4. Graphics/overlays.

Screen 4: Advance organizer for this training module. This screen demonstrates use of an advance organizer to orient the student:

1. Describe training goal.
2. Describe key sub-tasks.
3. Other.

Screen 5: Concept map. This screen demonstrates use of a Concept Map:

1. For complex tasks like information management we might want to provide the student with a “big picture” of how info is shared across staff, and between bn, co, and plt levels.

Screen 6: Reference to previously learned concepts. This slide demonstrates the cognitive principle of building on previously learned material:

1. Briefing bullets or other info display shows students’ linkages between previously learned material (in this case it might be menu navigation skills, and current task requirements).

Screen 7: Training of specific module task (actually multiple screens). Provides examples of cognitive techniques that facilitate training of specific skills:

1. Step-by-step training of task requirements, techniques match cognitive task demands.
2. Stress common mistakes/misunderstandings.
3. Automated “Help” or “Hint” features.
4. Possible role for instructor.

Screen 8: Collective training. Provides example of “constructivist” context-based training using scenarios:

1. Tasks such as information management might best be trained as a collective task with LAN-linked students sharing information vertically across staff positions, or horizontally across bn, co, plt.

Screen 9: Practical exercise. This slide demonstrates cognitive principle of rehearsal:

1. Screen(s) present student with opportunity to rehearse material learned in this lesson.
2. Might provide multiple practical exercises that student can select to practice until student judges that he knows the material.
3. Incorporate assessment and feedback mechanisms as possible.

Screen 10: Declarative knowledge assessment. This slide demonstrates assessment of declarative knowledge linked to long-term skill retention, automated performance assessment and feedback:

1. Multiple choice test of module concepts.
2. Should be machine scoreable, automated performance assessment.
3. Automated feedback should be possible, text describing why incorrect responses are incorrect.

Screen 11: Module navigation screen. This screen demonstrates flexible training that accommodates student needs:

1. Screen at end of module lets student choose to go on to next module, or return to home page.

# Appendix C

## Demonstration Mode Video Screen

### Prepare and Send Spot Report

**Spot Report process:**

```
graph LR; A[Initial Steps] --> B[Report Completion]; B --> C[Closing Steps];
```

- Initial Steps**
  - Messages
  - Create tab
  - Combat Messages
  - SPOT/SALUTE
- Report Completion**
  - Report Type and Unit
  - Entity Data
  - Course/Speed Data
  - Observation Data
- Closing Steps**
  - Save As
  - Send Report

(To restart a section, click on one of the process boxes)

#### Training Points

The video demonstration provides a 40 second preview of the expected training outcomes

#### Action

1	Select continue to begin training
---	-----------------------------------

**A video showing the entire process of creating a Spot Report runs...  
estimated time is approximately 40 seconds.**

Continue

Illustration from Deatz and Cobb (in preparation).

# Appendix D

## Student Subject Matter Review Screen

### Prepare and Send Spot Report

**Spot Report process:**

**Initial Steps**

**Report Completion**

**Closing Steps**

- Messages
- Create tab
- Combat Messages
- SPOT/SALUTE
- Report Type and Unit
- Entity Data
- Obs Equipment Data
- Observation Data
- Save As
- Send Report

(To restart a section, click on one of the process boxes)

1. Click Message Button
2. Click on the Create tab
3. Click on the Report button
4. Click on Spot Report option
5. Click on Long Form Message

#### Training Points

You are now finished with the initial steps of the Spot Report process, you will soon begin to complete the report after the review

#### Action

1	Click on Next below when ready to continue
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Illustration from Deatz and Cobb (in preparation).

# Appendix E

## Subject Matter Quiz Screen

**Prepare and Send Spot Report**

**Spot Report process:**

- Initial Steps**
  - Messages
  - Create tab
  - Combat Messages
  - SPOT/SALUTE
- Report Completion**
  - Report Type and Unit
  - Entity Data
  - Course/Speed Data
  - Observation Data
- Closing Steps**
  - Save As
  - Send Report

(To restart a section, click on one of the process boxes)

**Review**

After clicking on the message button, which tab should you select to start a new report?

- A. Manage
- B. Edit
- C. Create
- D. Send

**Messages**

Send Create Edit Print Manage Sent Queue

Msg Type

- Orders/Requests
- Fires/Alerts
- Reports
- Images/Videos
- Overlays

Transmission Settings... Quick Send Messages...

Execute Close Help

**Training Points**

**Action**

- 1 Click on the button for the best answer

Illustration from Deatz and Cobb (in preparation).