Techniques and Practices for Training Digital Operator Skills

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ABSTRACT

The Army Battle Command System (ABCS) is a force multiplier because it enhances the dissemination, analysis, and storage of critical battlefield information. Effective employment of this system in operational contexts requires well-trained Soldiers and leaders. To evaluate the effectiveness of digital system training, we examined the techniques and practices of ABCS instructors of four major ABCS systems.

This paper describes the training techniques of digital instructors from the standpoint of *cognitive*, *behavioral*, and *constructivist* theories and offers guidance for improvement based on the literature. A total of 24 days of training was observed across eight separate classes covering four ABCS systems. Observers recorded a number of instructional activities including the incidence of training techniques (e.g., use of memory aids, pointing out screen prompts and cues, emphasizing active learning) and classroom activities (e.g., lecture, guided demonstration, practical exercise). Instructors predominantly taught with cognitive and behavioral techniques such as demonstrating the steps of a task while the students repeated the steps on their own computer. Research has shown that constructivist techniques such as guided exploration can improve the acquisition and transfer of digital skills over the techniques currently in use; therefore, instructors would do well to incorporate these types of techniques into their teaching repertoire. In addition, best practices from across classrooms were identified and discussed.

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INTRODUCTION

In the present research effort, we investigated digital training practices in Army classrooms and assessed them from the standpoint of theories of learning. Before describing the process of data collection and analysis, it would be helpful to briefly discuss the three primary learning theories that we chose—*behaviorist, cognitive, and constructivist theories*.

The *behaviorist* approach to training applies especially to teaching new tasks because learning is best measured in terms of behavioral change. As Sanders (2001) explained, this theory views learning as a largely passive process in which exposure to the appropriate stimuli, reinforcement, and/or punishment leads to behavioral change. A key principle of behaviorism is that repetition of the stimulus and response (i.e., practice) strengthens learning and reduces decay.

The *cognitive* movement emerged in the 1960s and was in many ways a reaction to the refusal of most behaviorists to include mental events in the domain of psychology (Schultz & Schultz, 2004). *Cognitive* psychologists study human thought processes and they see the brain as a biological computer that assimilates, interprets, processes, and stores information. In contrast to behaviorism which sees the learner as passive, *cognitivism* regards the learner as an active participant in the learning process, organizing and assimilating new information into existing knowledge structure. It follows that the more the instructor can organize and present information in a logical fashion, the more easily the learner can assimilate the information. Using techniques such as advance organizers, analogies and mnemonics to relate new information to that already in the learner's knowledge base will facilitate learning.

Constructivism was developed not so much as a psychological theory but as an approach to training (Fox, 2001). In many ways it is a reaction to *cognitivism* but at the same time it shares many traits with that theory. Like *cognitivism*, *constructivism* is a theory about how individuals acquire, process, and store information; but unlike *cognitivism*, it sees learning as highly individual. *Constructivism* proposes that the way an individual understands and encodes new information is related to her/his unique history and personality. For example, if two people are asked to memorize strings of numbers, one may be a history buff who uses significant historical dates to help remember the assigned numbers while another might use his knowledge of baseball statistics to help remember the numbers.

Constructivism therefore questions the validity of pre-organizing material and requiring everyone to use the same training plan and mnemonics. *Constructivist* practitioners use training approaches known as problem-based learning, discovery learning, or experiential learning within a realistic task context (Ertmer & Newby, 1993; Kirschner, Sweller, & Clark, 2006). All of these learning approaches place the responsibility of organizing and making sense of the to-be-learned material on the shoulders of the learner. constructivists believe that an instructor should provide minimal guidance to students and should function more like a coach, encouraging students to explore and find answers on their own.

While theories of learning are broad models of how we learn, they give rise to more specific principles of learning (Merrill, 2002). An example of a principle of learning derived from *cognitive* theory is: "deep processing of information leads to better retention."

Learning principles such as this, give rise to specific training techniques. For example, having students apply something they have learned to solve a novel problem would require them to process what they have learned at a deeper level. Instructors can use training techniques without really understanding the learning principles or theories behind them; however instructors do need to understand that not all training techniques are effective in the same circumstances.

Sanders (2001) describes learning principles and associated training techniques relevant to the training of the Force XXI Battle Command Brigade and Below (FBCB2) system. Additionally, he addressed questions about when certain training techniques would be most useful. According to Sanders, *behaviorist* techniques would be best suited to basic procedural tasks but would not be well suited for more complex decision-making tasks. *Cognitive* techniques would be best suited for training declarative tasks and although they may take longer than behavioral techniques for training procedural tasks, he suggested that *cognitive* techniques would result in better retention of such tasks. Finally, Sanders suggested that *constructivist* techniques would be best suited for training ill-defined tasks such as decision-making at the brigade staff level.

In the present research effort, we sought to assess the training techniques commonly used during training for Army Battle Command System (ABCS) components including FBCB2, the Maneuver Control System (MCS), the All Source Analysis System (ASAS), and the Army Field Artillery Tactical Data System (AFATDS) to determine whether instructors were optimizing their use of these techniques. In addition, we tried to identify and disseminate the lessons learned and best practices of ABCS instructors.

METHOD

Overview

The research team targeted two installations where digital training courses are taught—Fort Hood, Texas and Fort Benning, Georgia. An observation protocol was developed that focused on learning principles and training techniques. The observation sessions yielded data on the training environment, instructional activities, and training techniques in use.

Techniques and Activities Observed

Based on previous observations of digital training, the research team realized that only selected classroom activities are typically employed. As a result, many of the general classroom activities addressed in U.S. Army Training and Doctrine Command (TRADOC) Regulation 350-70 (TRADOC, 1999) did not apply to the process for investigating contemporary ABCS training. The list of classroom activities selected for observation appears in Table 1.

Table 1. Classroom Activities and Techniques Selected for Observation Purposes

Activity	Description
Lecture	Oral presentation of information, typically accompanied by slides
Video	Film-based presentation of real-world scenes and/or animation
Demonstration	Illustration of steps/actions by demonstrator (students observe only)
Guided Demonstration	Performance of steps/actions by demonstrator (students replicate)
Practical Exercise	Scenario-based event requiring application of skills and knowledge
Review	Retrospective summary or recapitulation of key learning points
Test	Formal measurement of learning by means of quizzes, exams, etc.
Break	Temporary suspension of formal learning activities
Technique	**Description**
Emphasize practice	Provide repeated opportunities to perform tasks and correct errors
Check learning progress	Assess learning via questions, feedback, and performance monitoring
Point to screen prompts	Point out elements in slides or ABCS screen displays to guide learning
Use memory aids	Provide memory prompts and mnemonics to facilitate recall
Provide purpose and path	Specify course benchmarks or topics, and maintain path awareness
Relate to military operations	Put system functions in context of military knowledge or operations
Relate to general knowledge	Link system functions to general knowledge of computer capabilities
Relate to previous content	Build on knowledge and/or skills covered earlier in the course
Respond to learners	Provide information to satisfy student questions or requests
Encourage active learning	Promote student involvement by means of instructor's challenges

The ten specific techniques that were selected for observation were based on other research reports (Dyer, Singh, & Clark, 2005; Sanders, 2001) and were activities that we believed could be recorded in real-time with a high degree of reliability. They also represented the different theoretical perspectives discussed in the introduction and covered the majority of instructor activities typically used. Because the list was not considered to be comprehensive, observers had space on the form to describe additional instructor activities not on the list.

The observation form was structured so that observers could record activities chronologically. Observations were recorded once every five minutes at which point the observer indicated all activities and training techniques observed within that five minute block. If any activity or technique was observed at least once during a given five minute observation block, it was recorded on the observation form. Observers also had space to briefly describe specific instructor and student behaviors, topics covered, etc. during each block of observation.

The resolution of the observation form was limited to five minute blocks of time to improve the reliability of the observations. During pilot testing it was almost impossible to get consensus among observers when recording exact start and stop times of all eight activities and ten techniques in real time. For this reason, the quantitative data are reported in terms of the number of blocks in which the event was observed.

Observers also recorded observations about how instructors assessed student experience and knowledge at the beginning of the course, innovative training techniques employed by the instructors, and how the students were assessed at the end of the course.

Observation Protocol

Four subject matter experts collected data, two at Fort Hood and two at Fort Benning. Three of the observers were retired Army personnel with experience using ABCS systems and training digital skills. The fourth observer was a behavioral scientist with ABCS training. Each of the four observers had experience observing classroom training in Army schools and/or training centers.

Two types of digital system courses were observed. One was geared towards operators and ranged from 40 to 80 hours of instruction. The other served to provide leaders with an overview of the system. These familiarization courses were only 16 hours.

For the two-day courses every day of classes was observed. In the case of the longer courses, three to four days were observed, with the general intent of sampling the first, middle and end (preceding the final exam) of the course. The observation plan called for bypassing formal test sessions because they were expected to yield relatively low payoff with respect to describing the instructional strategies reflected in the courses. The courses observed, duration of the courses, and number of days observed are summarized in Table 2.

Table 2. ABCS Training Courses Observed

Course	Training Audience	Duration	Observed
MCS	Operators	5 days	4 days
AFATDS	Operators	10 days	4 days
ASAS-L	Operators	10 days	4 days
FBCB2	Operators	6 days	3 days
FBCB2	Operators	6 days	3 days
MCS	Leaders	2 days	2 days
FBCB2	Leaders	2 days	2 days
FBCB2	Leaders	2 days	2 days

There was a total of 70 students in the operator courses. Of those, 34 were contractors, 24 were enlisted, and 8 were noncommissioned officers (NCOs). There were 82 students in the leader courses and they were almost evenly divided between NCOs and Officers (48% vs 52% respectively).

RESULTS

Classroom Facilities

In all of the classrooms, students had a desktop computer running a current version of the ABCS system they were training on. Students also had a view of the instructors workstation projected onto an overhead screen. All computers were networked together so that the systems could share information much as they would on the battlefield. In every classroom, there was an instructor and an assistant instructor. These two individuals typically alternated roles throughout each course.

Instructor Activities

By a sizable margin, the most frequent activity was guided demonstration (see Table 3). This activity took place in over half of the blocks in both the operator and leader classes. Practical exercises accounted for from one-fifth to over a quarter of the total time blocks. Lecture occurred in about 30% of the blocks for the leader courses but only 15% of the blocks for the operator courses. Review of previous materials, including review of practical exercises, generally occurred infrequently, but it appeared in a quarter to a half of the blocks during 3 of the 18 days observed for the operator classes.

Three activities were almost never observed. These were testing, video, and, demonstration. Videos were typically shown at the beginning of a course as a means of providing an overview of the ABCS systems. Formal paper and pencil testing was observed only four times during the eight courses sampled.

Table 3. Percent of Blocks in which Instructional Activities Occurred For Operator and Leader Courses

Activity	Operator	Leader
Guided Demo	62%	53%
Practical Exercise	21%	28%
Lecture	15%	32%
Review	10%	4%
Test	2%	0%
Video	1%	1%
Demo	0%	0%

Note: Because more than one activity could occur in each block, percents do not total to 100.

Practical Exercises (PEs) were categorized as either a PE led much like a guided demonstration (Guided Exercise), an exact repeat of an earlier demonstration (Repeat Demo), a problem similar to an earlier guided demonstration with some variation (New Situation), or a problem that required the integration of multiple previously learned tasks (Integrate Prior Tasks).

Table 4. Percentages of Practical Exercises Falling Into Each of the Scored Categories

Type of PE	Operator Course	Leader Course
Integrate Prior Tasks	44%	22%
Repeat Demo	39%	37%
New Situation	11%	37%
Guided Exercise	6%	4%

Note: Due to rounding, these percents do not total to 100.

As can be seen in Table 4, in the operator courses, Integrate Prior Tasks was emphasized more than in the leader courses. On the other hand, New Situation was seen more frequently in the Leader Courses. In both types of course, Guided Exercise was rarely observed. While no orientation course involved a final exam, every operator course included a final exam as a capstone event. Every exam included a hands-on component instructing the student to perform specific operating tasks and/or steps. While the exams emphasized hands-on performance, all but one of them included a written component. All exams except one were graded as Go/No Go and in two courses, the final PEs were open-book.

Training Techniques

Within the context of various classroom activities, there were 10 training techniques observed (see Table 1 above).

As can be seen in Figure 1, the most commonly observed technique was pointing out screen prompts. The high frequency of this technique is due to the fact that it is almost an inherent component of performing a guided demonstration because the instructor typically spends much of the time pointing out relevant screen prompts to the students.

The significant disparity between the operator and leader courses regarding presenting the purpose and path is skewed by a single instructor in one of the FBCB2 operator classes who explained the operational path or flow of steps from memory.

Similarly, the higher frequency of relating the material to military operations in the leader courses relative to the operator courses is largely due to an active duty FBCB2 instructor (the only instructor in all courses who was not a contractor) and had formerly been deployed to Iraq. This instructor related almost every task to military operations.

In all operator and leader courses, four training techniques appeared rarely: (a) emphasizing practice, (b) using memory aids, (c) relating materials to general knowledge, and (d) encouraging active learning.

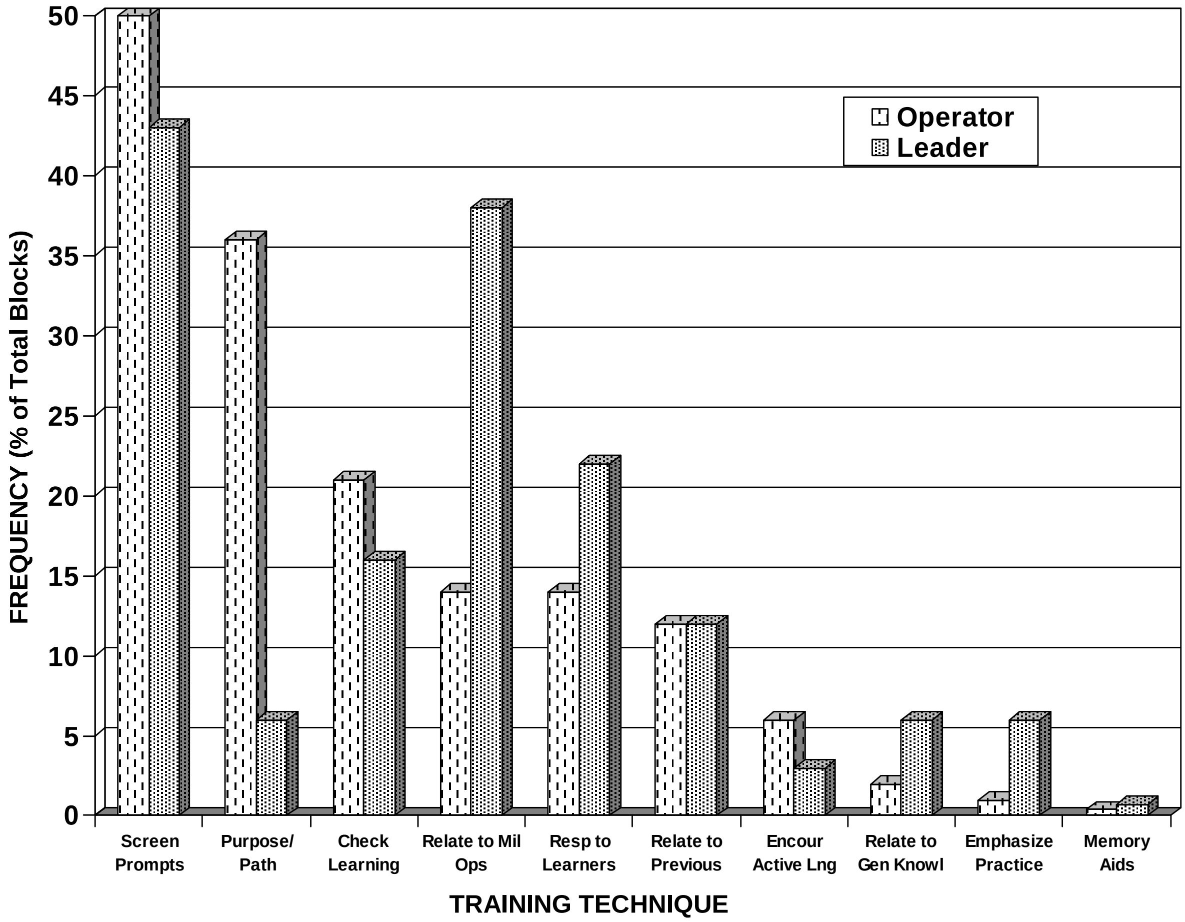

Figure 1. Frequency of the 10 training techniques by type of course

Innovative Techniques

One of the data capture items on the observation form asked the observer to describe any innovative teaching techniques used in the classroom. This yielded the following:

- In the FBCB2 courses in both locations, the instructors selected one of the more capable students to serve as a demonstrator.
- Peer coaching was observed in all eight courses, although it was unclear whether the instructors encouraged this or it emerged spontaneously, or both.
- When a student asked "how can I" or "what if" questions, one instructor had the individual try out the procedure in question (ICCC orientation).
- The AFATDS instructor team referenced some of their guided demonstrations to specific pages in a system pocket guide, apparently as a procedural aid.
- In the MCS orientation course, the instructor reinforced using the workstation by having students obtain quiz and exercise materials from a shared (networked) folder.
- The instructors of one of the FBCB2 operator courses asked students to answer questions on a PE sheet as relevant topics were covered on Day 1.
- In addition to sharing their own combat experiences, the instructors of an FBCB2 operator course had the students share operational anecdotes.
- During one of the scenario-based exercises (a CPX during AFATDS training), the instructors role played external personnel (e.g., battalion commander).
- In the ASAS-L classroom, the instructors posted screen shots of various operating displays on the walls for ABCS ambience.

- In at least one course the instructors provided software on compact disc that enabled students to practice on their work or personal computers.

Integration of Theory with Training Methods

The classroom activities and training techniques (shown earlier in Table 1) used to characterize instructional activities were related to the three learning theories. Additionally, other elements of the recorded data aligned with the learning theories. For example, conducting guided demonstrations (one of the instructional activities) represented the *cognitive* learning principle of involving students in the learning process.

Table 5 combines the classroom activities, training techniques, and PE methods and groups them according to the three theories of learning described in the Introduction. Because all theories highlight the importance of practice and instructor feedback, methods associated with these two learning principles are not associated with any specific theory of learning. Certain instructional activities (i.e., lecture and video) are excluded from Table 5 because it is difficult to associate them with any one theory of learning.

It is important to note that there are no hard and fast rules on which methods go with which theories of learning. The groupings in Table 5 represent the authors' opinions on how these assignments should be made. It is not the authors' position that this is the only possible way to group these methods.

As can be seen in Table 5 there is a clear tendency for instructors to rely on *cognitive* approaches to accomplish training. As previously stated, instructors spent a majority of planned instruction time conducting guided demonstrations and relating new material to the students' military knowledge as well as to other material taught in the course. Besides pointing out screen prompts and cues, no other *behaviorist* approaches were used. It should be noted that although providing practice is a component of all theories, it is a prominent feature of behaviorism. Finally, the only *constructivist* technique employed with any frequency was to respond to learners' concerns and needs.

Table 5. Summary of Theory-Based Methods Observed in ABCS Classrooms, by Type of Course

		Rate (per Block)	
Theory	Method (Training Technique or Activity)	Operator Courses	Leader Courses
All (Provide Practice)	Focus exercises on job duties (PEC)	.16	.08
	Integrate prior tasks/skills in practical exercises (PEC)	.11	.05
	Structure exercises around repeat of demonstration (PEC)	.05	.10
	Focus exercises on military operations (PEC)	.02	.20
	Emphasize hands-on practice (TT)	.01	.06
	Frame exercises in new situations (PEC)	.01	.13
	Conduct guided practical exercises (PEC)	.002	.007
	Situate practical exercises in an arbitrary context (PEC)	0	.003
All (Provide Feedback)	Check progress of student learning (TT)	.21	.16
	Provide peer coaching during exercises (PEC)	.06	.28
	Test learning by means of quizzes (CA)	.02	.003
Behaviorist	Point out screen cues and prompts (TT)	.50	.43
	Use memory aids to cue recall (TT)	.004	.007
	Perform demonstration of steps (CA)	0	.003
Cognitive	Conduct guided demonstration (participative) (CA)	.62	.53
	Explain learning purpose and path (TT)	.36	.06
	Relate new material to military operations (TT)	.14	.38
	Relate new material to previous content (TT)	.12	.12
	Relate new material to general knowledge (TT)	.02	.06
Constructivist	Respond to learners’ concerns and needs (TT)	.14	.22
	Review previous materials to strengthen learning (CA)	.10	.04
	Encourage active learning (TT)	.06	.03

Note: CA = classroom activity; TT = training technique; PEC = practical exercise code.

DISCUSSION

The three learning theories highlighted at the start of this report—*behaviorist*, *cognitive*, and *constructivist*—provide a useful framework for characterizing the state of ABCS training methods. They also offer a conceptual basis for discerning ways to improve the methods used to conduct digital training in the classroom.

When looking across all instructional activities, training techniques, and PE parameters, two clearly dominated the curriculum: guided demonstrations and pointing out screen cues and prompts (occurring in roughly 45-60% of the blocks). None of the *constructivist* methods in Table 5 occurred at high rates. Limited use of *constructivist* techniques is indicative of training intended for the novice student. As Clark and Wittrock (2000) point out, these types of *cognitive* and *behavioral* techniques work better for novices than do *constructivist* approaches. Similar conclusions have been reached by other researchers (Ertmer & Newby, 1993; Goodwin, 2006; Sanders 2001).

Nevertheless, it would likely be beneficial to incorporate more *constructivist* techniques such as guided exploration into the digital training curriculum for several reasons. First, although the operator and orientation courses are designed for novices, many of the students attending them are experienced users of the systems. Further, by the end of a 40-80 hr course, it is likely that few novices remain amongst the student population. Research suggests that instructors should consider using *constructivist* approaches, especially towards the end of the operator courses and given these methods have shown measurable benefits over the traditional *behavioral* and *cognitive* approaches when training ASAS and AFATDS operators (e.g., Childs, Schaab, & Blankenbeckler, 2002; Schaab & Dressel, 2001). Second, as discussed by Goodwin (2006), guided exploration has proven a superior training technique to guided demonstration in a number of experiments, even when used with novice students.

Guided exploration is a technique whereby the learner is given just enough information to solve a problem, but he is encouraged to solve the problem on his own rather than having the instructor walk him through the solution. In this way, the student is more actively engaged in understanding the solution and is more likely to recall and transfer the knowledge later (Goodwin, 2006).

The optimal place to insert *constructivist* techniques like guided exploration would be during the PEs as it would require the smallest change in the program of instruction (POI). For example, having students integrate prior tasks and skills with newly learned ones, without first being shown step-by-step how to do it, would reinforce prior training and require students to master an ever increasing skill set. Additionally, instructors could avoid PEs that simply repeat prior guided demonstrations by having students apply what they have learned to solve novel problems without first being shown the solution.

Many of the training methods in Table 5 occurred rarely (less than 5% of the blocks). When observing individual courses by days, some techniques were completely absent in the classroom. However, low frequency does not necessarily indicate a given method has no place or value in the digital classroom. The merit of a candidate training technique depends on the learning objectives, training audience, time available, equipment on hand, student aptitudes and abilities, instructors available, and other factors. Thus, a low rate of occurrence should not deter an instructor from considering a particular technique. In fact, low density training methods may represent opportunities to increase the variety of learning experiences in classroom sessions. For example, instructors rarely demonstrated a task while the students merely observed. If the guided demonstration is the first time a student is seeing a task performed, that student's attention is divided between observing what the instructor is doing and trying to mimic it on his or her own system. This leaves little mental reserve to process or encode the steps being performed and consequently may result in faster skill decay.

Demonstration was used effectively during the New Equipment Training (NET) for the Land Warrior (LW) system as documented by Dyer and Tucker (2007). Demonstrations were always given before students attempted to execute PEs. Differences between the results in the current research and the LW NET may reflect instructor differences or that it is difficult for a Soldier to operate the LW equipment he is wearing and simultaneously attend to procedures being demonstrated. In addition, during NET, the classes were large (approximately 100 students), increasing the difficulty of insuring the pace of the instructor matched that of each student. However, it should be noted that the demonstration technique has been observed in other LW training, with smaller class sizes (e.g., 40 and 9 students, Dyer et al., 2000; Dyer & Wampler, 2002).

As seen in Table 5, the *cognitive* method of relating instruction to general knowledge was absent or nearly so in most courses. The consistency of the pattern across courses suggests that ABCS instructors did not find this technique useful or necessary, or that training developers did not consider the technique when designing and developing the course materials. This indicates that ABCS training is not capitalizing on relevant results reported by other researchers. For example, research has shown that if the functions of a military digital system are similar to Microsoft Windows, e-mail, or internet applications familiar to Soldiers, instructors can leverage the similarities so that Soldiers more readily learn to operate and understand how to apply new system software (Singh & Dyer, 2001; Wampler et al., 2006).

The *behaviorist* and *cognitive* principles of pre-assessing students to enable tailored instruction was not evident in any of the ABCS courses sampled. The instructors typically queried the students at the start of the course to get a feeling for their range of experience, using an informal process. The students varied considerably in their previous experience with ABCS and related systems. Some had no ABCS experience, while others had worked with multiple ABCS systems during a combat deployment. The instructors appeared to identify the more advanced students, but aside from using them as demonstrators or asking them to share experiences with the class, instructors rarely tried to use their expertise to facilitate training.

Although all courses were designed for the novice, some form of diagnostic test at the start of a course could have been helpful. Such testing would enable instructors to tailor the training sessions (within limits) and take advantage of the students with ABCS experience. For example, if most of the students had previous ABCS experience, instructors might consider using more advanced PEs. On the other hand, if the class included advanced and novice students, instructors could either divide students into two groups, based on experience level, or team the more experienced students with less experienced students so that the former could help instruct the latter.

Instructional Innovation

Several instructional innovations were observed and these predominantly fell into categories of making learning more active and using expert students. To encourage active learning, instructors would have students to develop solutions to their own questions, answer questions on a handout as the course progressed, or have students use their systems to retrieve PE materials.

Instructors who used expert students had them serve as demonstrators by projecting the expert student's computer screen through the overhead so others could watch as the more experienced student worked through the exercise. Further, instructors asked experienced students to share their experiences with the classroom.

Other innovative ideas included providing ancillary materials such as posters, CDs, or references to serve as memory aids and to help Soldiers do refresher training.

Conclusions

Current ABCS courses rely heavily on the use of guided demonstrations and PEs as instructional methods. These techniques draw from *cognitive* and *behaviorist* theories and are effective for training novices. Instructors might improve the acquisition, retention, and transfer of digital skills by increasing their use of *constructivist* techniques such as guided exploration. In addition, instructors should avoid overloading students with new information, especially with complex tasks, by demonstrating some tasks before asking the students to follow along on their own systems.

Finally, instructors would do well to take the time to assess the proficiency of students at the beginning of instruction and to better leverage the expertise of experienced students. Experienced students would benefit the classroom by tutoring less experienced students. Alternatively, a generally experienced class might benefit from a more advanced POI.

The instructors we observed were uniformly hard working and highly motivated to provide the best possible instruction. Soldiers who take these classes get excellent training, but the current operational tempo has often resulted in demands that instructors provide more training with less time. Future research is needed to help instructors respond to this pressure by empirically testing the recommendations in this paper and by determining the most effective ways to implement them.

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