EMBEDDED TRAINING and USER ASSISTANCE

THE CURE FOR PERFORMANCE PARALYSIS

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I certify that this is my original work, and that it has not been previously accepted for publication.

ABSTRACT

Future warfare will rely on complex information systems. Our soldiers will need frequent and up-to-date training on those systems. But training resources are shrinking and are expected to continue to shrink. Part of the solution to this problem is to develop training technologies that are more effective and efficient than current conventional methods. The other part of the solution is to provide our soldiers with information systems that have a user assistance capability.

Embedded training is an alternative that might satisfy both of these needs. This article discusses an analysis that was conducted to determine if embedded training is as effective and efficient as conventional instruction techniques. It also determined if embedded training should be used to provide the needed user assistance capability. The analysis used the results and findings from other studies on embedded training, or computer-based instruction, to draw conclusions and make recommendations. The recommendations are that embedded training should be built into the design and delivery of military training programs and future information systems. More specifically, interactive multimedia, simple tutorials, and simulations should be used as the primary embedded technologies. Operational user assistance should be based on these three technologies and should be accessed by using a standard help screen or menu.

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> ***National Military Strategy, 1997***
> **Only the most dedicated, well-trained personnel with first class leaders will succeed in the complex and fast-paced environment of future military operations.**

This article discusses the results of an analysis conducted to determine if embedded training is as effective and efficient as conventional platform-based training. A secondary purpose was to determine if embedded training could provide our soldiers with the "user assistance" they will need to operate the highly technical information systems of the future. If embedded training is as effective and efficient as our conventional platform-based instruction, then it should be built into the design and delivery of military training programs and future information systems. Additionally, if embedded training can provide the needed user assistance capabilities, then those capabilities should be built into our future information systems.

THE FUTURE. The "visions" of the future establish our reliance on information technology and the enablers of that technology. Complex automated information systems will increase situational awareness by creating a common, relevant picture of the battlefield. This increased situational awareness will allow us to shape the battlespace and exploit the enemy's weaknesses. Future commanders will "assimilate" this vast amount of information to "maintain or accelerate the pace of battle" and quickly and decisively

> ***Joint Vision 2010***
> We must have information superiority: the capability to collect, process, and disseminate an uninterrupted flow of information while exploiting or denying an adversary's ability to do the same.
>
> ***Army Vision 2010***
> Shaping the battlespace will be facilitated primarily by sharing "real time" information among all Services, allies, and coalition partners. This process will be accomplished by effectively exploiting information age technologies… processing and fusing multiple sources of information from all involved components; and employing the proper force, munitions, or energy before the target is lost.
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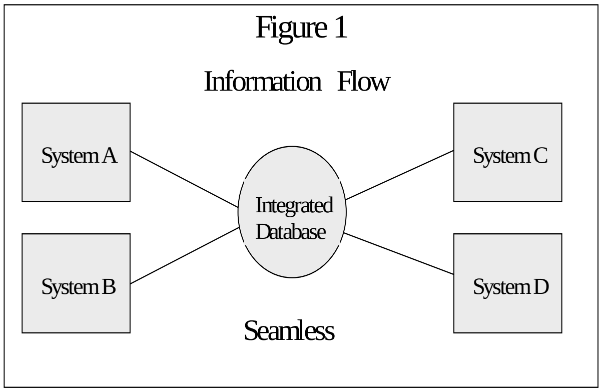
> ***DA Pam 100-1***
> ***Force XXI Institutional Army Redesign***
> Army XXI operations will be designed to control-maintain or accelerate as necessary-the pace of battlefield events. Commanding under these conditions will require commanders who can assimilate thousands of bits of information to visualize the battlefield, assess the situation and direct the military action to achieve victory.

achieve victory. But there is a problem—commanders will not operate this complex equipment—soldiers will. How will the concepts in these corporate-level, forward-looking documents affect the soldier?

THE PROBLEM. The problem is two-fold: 1) soldiers will need user assistance when operating future information systems, and 2) they will also need training that is more effective and efficient than our conventional methods. In the not-so-distant future, our soldiers will sort through and manage vast amounts of information using high-tech information systems. These systems will be resident on computers that are periodically updated with newer versions of the software. How will our soldiers perform in this high-tech, changing environment? A trained soldier may operate with the speed and agility necessary to support the increased operational tempo on the future battlefield. But, an untrained or inexperienced soldier may be overwhelmed by the sheer mass of information trying to climb into his computer. And once it's there, given the gravity of a misplaced keystroke or mouse click, the soldier might well experience "performance paralysis." New information systems must contain a user assistance capability to prevent this "paralysis" from occurring. In addition, our soldiers will need increased opportunities to train. That training will need to be innovative and based on the latest system upgrades. But, operational tempo and ammunition costs are increasing and are expected to continue to increase. Available maneuver and range land are decreasing and that trend is expected to continue also ("How The Army Runs", 1997-1998). In short, our training resources are shrinking and are expected to continue to shrink. Why does this pose a problem? What would be the impact if the Army does not provide our soldiers with 1) information systems that have a user assistance capability and 2) more effective and efficient training, which leads to increased opportunities to train?

IMPACT OF THE PROBLEM. Our new information systems and enablers are being designed to support a seamless flow of information on the future battlefield (see Figure 1). Each system will provide and extract "real time" data to and from a common database. The reliability of this seamless system will depend on the reliability of each of the subsystems. One untrained or



inexperienced soldier (of the hundreds in the system) stuck in "performance paralysis" could potentially disrupt this seamless flow. Data that is assumed to be "real time" might actually be several hours old. Decisions based on this old data may result in unsynchronized battlefield operations, missed targeting opportunities, or the inability to manage resupply velocity.

AN ALTERNATIVE. Embedded training resides on or is added onto operational equipment and systems (TRADOC PAM 350-70-xx, Jun 96). Resident embedded training is built into the system software and add-on capabilities may come in the form of a CD-ROM. This embedded capability can come in the form of many different training and performance support technologies. Traditional technologies, such as tutorials and interactive multimedia, can be used to sustain or enhance (during system software updates) a soldier's level of performance. But embedded training also includes non-traditional technologies, such as simulations and "intelligent coaches." A simulation can be used to sustain or enhance the performance of crews and battle staffs. An "intelligent coach" is a type of performance support system that uses artificial intelligence. It is operationally oriented and interprets the user's level of proficiency, learning manner, and immediate needs by monitoring his actions. It tailors information presentation to the user to coach him in correct or even better ways to use the operational system (TRADOC Pam 350-70-xx, Jun 96). While all of these embedded training technologies are different, they each have something in common—all are available to the soldier when and where he needs them.

THE ANALYSIS. The focus of the analysis was to determine 1) if embedded training can provide the needed user assistance to system operators, and 2) if embedded training is as effective and efficient as conventional training methods. The first step in the analysis was to define effectiveness, efficiency, and user assistance. The next step was to locate the data needed to make the comparisons between embedded training and conventional training methods. Time did not permit the collection and analysis of raw data; therefore, this step focused on collecting the results and findings of other studies and analyses on embedded training and computer-based instruction. The last step in the analysis was to draw conclusions and make recommendations based on the findings.

Effectiveness is the degree to which a soldier can perform his stated task or mission. For example, a soldier is effective if he can accomplish a task to standard. For our purposes, there are two types of effectiveness—training and cost. Training effectiveness measures the ability to accomplish a given level of achievement. Cost effectiveness measures the costs associated with attaining that given level of achievement. It can be measured by varying the instructional technique (and thus the costs) while holding the level of achievement constant.

Efficiency considers the soldier's level of performance. It is also considered to be the rate of task accomplishment, which involves both time and achievement. For our purposes, efficiency is the time required to accomplish a given task, while holding the level of achievement constant.

An example may show the difference between effectiveness and efficiency. Assume two soldiers are being evaluated at a rifle range to determine how many bullets are required for them to hit ten targets. The first soldier hits ten targets with thirteen rounds of ammunition and the second soldier hits ten targets with ten rounds. The soldiers are equally effective, but the second soldier is more efficient than the first. This is an example of holding effectiveness constant (hit ten targets) while varying what it takes (bullets, time, or costs) to achieve that level of effectiveness.

User assistance helps the operator work through system problems that occur during actual operations. These job aids (sometimes called wizards) are embedded in the system's software. User assistance capabilities range from standard help screens to "intelligent coaches." The user accesses help screens through the help menu. "Intelligent coaches" use knowledge-based artificial intelligence to make inferences about the users actions and prompt the user for more information. Based on the user's response and the knowledge it has already accumulated, the coach might recommend a course of action to the user. Eventually, the individual will learn to use the system and the "intelligent coach" will not be needed for that specific task again.

FINDINGS. A large number of studies have been completed on computer-based instruction. Quantitative data was readily available on training effectiveness, cost effectiveness, and efficiency. But the data on user assistance was largely qualitative. The findings are discussed below by category.

Training Effectiveness. In a summary analysis, Fletcher (1996) compiled the results of numerous other analyses that compared different training technologies to conventional instruction. He used a statistical procedure to make inferences about the students' increase in achievement. Tables 1 and 2 show his results for computer-based instruction and interactive videodisc (interactive multimedia), respectively. The last column in the table shows how much more a 50th percentile student could achieve given the use of the technology.

Table 1, Effects of Computer-Based Instruction

Where	No. of Studies	From 50th percentile To:
Elementary School	28	68th percentile
Secondary School	42	66th percentile
Higher Education	101	60th percentile
Adult Education	24	66th percentile
Military Education	38	66th percentile
Overall	**233**	**65th percentile**

Table 2, Effects of Interactive Videodisc Instruction

Where	No. of Studies	From 50th percentile To:
Military Training	24	65th percentile
Industrial Training	9	70th percentile
Higher Education	14	75th percentile
Overall	**47**	**69th percentile**

Fletcher's findings are powerful in that they are based on the results of several other studies (see "No. of Studies" in the tables) and draw a cumulative picture of the effects. For example, his findings summarized the results of 233 studies to suggest that computer-based instruction increases the achievement of a 50th percentile student to 65th percentile. Fletcher's research showed that student interactivity increases the effectiveness of training. He also found that training effectiveness increased (from 50th to 66th percentile) if students used simulations (vice the actual equipment) when learning to maintain and repair equipment. These findings clearly show that computer-based technologies increase training effectiveness.

Cost Effectiveness. Fletcher (1996) also summarized the cost data provided in several studies. He calculated the costs (in constant 1985 dollars) to increase mathematics scores by the same amount using tutors, reducing class size, increasing instructional time, and providing computer-based instruction. Table 3 shows the results of his analysis.

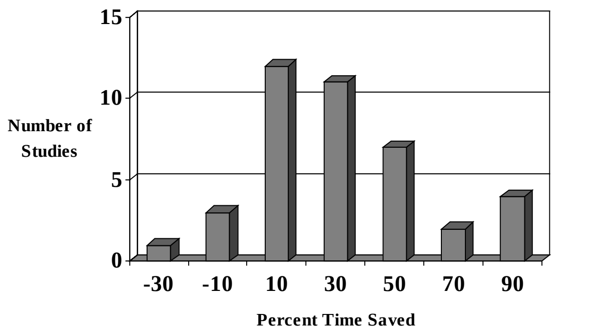
Table 3, Cost Effectiveness

Alternative		**Cost**
Tutoring (20 Min/Day)	Peers	286
	Adults	1612
Reduce Class Size From:	35 to 30	983
	30 to 25	1171
	25 to 20	1367
	35 to 20	1195
Increase Instruction Time to 30 Min/Day		2667
Computer Based Instruction for 10 Min/Day	Grade 3 (Calif.)	338
	Grade 3 (Miss.)	208
	Grade 5 (Calif.)	462
	Grade 5 (Miss.)	490
Microcomputers in Classroom (1990)	Grade 3	192
	Grade 5	206
Costs are shown in constant 1985 dollars.		

The most cost-effective alternatives were computer-based instruction and peer tutoring. Fletcher also suggested that a "very strong cost-effectiveness argument might be made for peer tutoring combined with computer-based instruction."

Efficiency. One analysis summarized the results of 40 studies comparing the efficiencies of computer-based and standard training in the Navy, Army, and Air Force (Orlansky and String, 1979). Thirty-six studies reported that students in computer-based courses finished in less time (Figure 2). Overall, students in computer-based courses finished lessons in about 30 percent less time than that allotted for conventional courses. Other studies found that students met standards

Figure 2
Efficiency of Computer Based Instruction



in 34 percent less time (Kulik, 1994) and 31 percent less time (Fletcher, 1990). These findings show that computer-based instruction is about 30 percent more efficient than conventional methods of instruction.

Montague and Knirk (1998, Item 30) suggest that these gains in effectiveness and efficiency "did not result simply from using computers in instruction but from imposing a systems approach for design on the courses and allowing students to progress at their own learning rates." They do not expect these gains in effectiveness for military students because our courses have already been designed using a systems approach. However, they do expect the gains in efficiency. They suggest that each situation be evaluated to determine if cost-effectiveness justifies its use.

User Assistance. Studies have been completed showing the effects of using a tutor on student achievement. While this is not embedded user assistance, it is an example of individualizing instruction to the student's needs. But one instructor for each military student is not economically feasible. Bloom (1984) suggested that computer-based instruction might replace some of this lost individualization. He analyzed the difference between students taught in classroom groups of 30 and students who were tutored (one-on-one). He found that tutoring average students increased their level of achievement to the 98th percentile. Another study showed that while simulations can be used to increase training effectiveness, the magnitude of that increase is higher if a student receives tutorial guidance along with the simulation (Fletcher, 1996). This seems to be especially true if the student is a beginner—naïve students need more guidance (Gay, 1986). These findings appear to support the need for capabilities similar to those offered by tutors.

Few studies have been completed on the use of artificial intelligence (intelligent tutors or coaches) in embedded training or computer-based instruction, particularly with respect to its effectiveness. One article (NATO, 1998) suggests that more research is needed to determine the best method of capturing what the student needs to learn. Some experts believe that this can best be accomplished by 1) determining what the student knows, 2) determining what the instructor knows, and 3) overlaying the two to determine what the student needs to learn. Other experts believe that "misconception" is a problem. Just because a student gives a wrong answer does not necessarily mean he does not know the correct answer. He may not have understood the question—a misconception. Should intelligent tutors identify these misconceptions? These issues require more research before informed decisions can be made.

CONCLUSIONS. The conclusions are derived directly from the analysis and are listed below.

- Overall, embedded training, or computer-based instruction, is more effective (both training and cost) and efficient than conventional, lecture-based instruction.
- Interactive multimedia is more effective and efficient than conventional instruction.
- Simulations are more training-effective than conventional training methods. Training effectiveness increases if tutors are used with simulations.
- The individualized treatment used in tutoring a single student is also a very effective method of training. Peer tutoring is more cost-effective than one-on-one instructor tutoring.
- More research is required on embedded artificial intelligence (intelligent coaches).

RECOMMENDATIONS. Embedded training should be built into the design and delivery of military training programs and future information systems. Interactive multimedia, simple tutorials, and simulations should be used as the primary embedded technologies. If possible, users (especially beginners) should be tutored by a peer when conducting training.

Operational user assistance should be limited to these three embedded technologies and should be accessed through a standard help screen (requested by the user). And finally, more research should be conducted on creating “intelligent tutors.”

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