INSTRUCTIONAL TECHNOLOGIES FOR EMBEDDED TRAINING

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ABSTRACT

It has been proposed that embedding training in operational military weapon systems can aid in achieving the goal of improved readiness. An analysis of embedded training goals and the potential contribution of embedded training toward enhancing personnel readiness was conducted. The emphasis in this specific project was the instructional technology requirements for embedded training, as opposed to the numerous engineering requirements relating to safety, reliability, etc. This analysis indicated that the advantages of shore-based training, particularly with respect to instructor functions, could be compromised in the embedded training environment. On the other hand, the fidelity and accessibility of training would be promoted by embedding training in operational equipment. To overcome this potential compromise of instructor functions, an evaluation of four instructional features, which could be implemented in the embedded training software, was undertaken. The instructional technologies under examination include: automated adaptive instruction, automated expository feedback, intelligent platforms, and simulation of missing team members. This paper will discuss the completed initial analysis and describe the research in progress. Initial data collected shall be summarized at the conference presentation.

I. INTRODUCTION

The military strategy supported by the United States is based upon a wide range of potential conflicts. This "Spectrum of Conflicts" ranges from a peace time show of military presence to strategic nuclear war. This translates into the requirement to counter enemy initiatives from air, land, and sea. With respect to the Navy, this counter capability becomes the application of Navy tasks such as antisubmarine warfare, antisurface warfare, antiair warfare, counter command and control, mine operations, amphibious operations, strike operations, sealift operations and special operations.

The primary threat today is represented by growing Soviet forces. To counter this Soviet threat, the United States has developed and implemented high technology to train personnel to effectively deploy their tactical systems. With the increasing complexity of these systems, the demands required of personnel to effectively apply U.S. tactics have increased. Readiness of personnel and systems is necessary to implement U.S. strategy. Of particular concern to this project is the training component of the personnel readiness factor.

Perishability refers to a degradation in the individual's ability to apply knowledge through behavior, either cognitive or psychomotor. For example, in October, 1985, COMNAVSURFLANT reported on an exercise relative to the Level of Professional Readiness (LPR) of Electronic Warfare (EW) specialists. The report indicated that the LPR did not improve from initial performance following "A" school through to retirement. This means that the skills learned in "C" schools and traditional OJT following "A" school perish over time and, in general, are not maintained or further developed as a function of job activities.

To attempt to counter this degradation in skill proficiency, the Navy requires additional training in those skill and knowledge areas where there is infrequent application of specific behaviors. Training systems of all types, ranging from shore-based, full mission simulators to desk top microprocessors which provide environments sufficient to train part tasks, are available to provide training. Such systems, however, are either not easily accessible or lack full mission capabilities. Another strategy has involved the development of pierside trainers. These are mobile containers which are trucked to the pier beside a docked ship and stimulate the equipment on board ship. Although the fidelity issue is nicely handled, problems with accessibility still remain, since it takes considerable time and numerous personnel to make all the necessary interfaces to the vessel's equipment, and a limited number of trainers must service an entire class of ships.

It has therefore been proposed that high fidelity of simulation and direct accessibility to trainers comes with a concept called Embedded Training (ET).

II. SHORTFALL

There are numerous definitions of embedded training but for now we shall refer to that provided in the DRAFT OPNAVINST on Embedded Training paragraph 4.1., Task Force on Embedded Training and the Flag-Level Steering Group on Embedded Training, 14 Nov. '85. "Embedded Training is training that is provided by capabilities built into or added onto operational systems, subsystems or equipment to enhance and maintain the skill proficiency of the fleet."

Much discussion, analysis, and research has been generated with regard to the engineering requirements for embedding training sub-systems in weapon systems under development and planned for the future. These engineering requirements emphasize safe reliable equipment with lock-out to weapon firing, immediate transfer from training mode to full system operational mode on demand, computer sizing, simulation vs. stimulation, strap on vs. full integration, etc. Other hardware technologies identified under engineering requirements for ET include such capabilities as voice recognition and computer generated imagery. The emphasis of this specific project is the instructional technology requirements for ET as opposed to the numerous engineering requirements.

III. APPROACH

Analysis of information published or available on 38 training systems identified by various sources as "embedded" (Table 1), as well as the wider literature on training technology, has led us to believe that most of the features of shore based training that are lost when training becomes embedded relate to the dimension of instructional technology. By embedding training in operational systems on a platform, many of the advantages of shore based training are removed. For example, one is now faced on board with the problems of

* providing a structured educational environment for training skills and knowledge

* providing interaction between students and instructor

* the absence of a large cadre of qualified instructors to assess performance, play other roles in scenarios, control targets, etc.

* the current absence of techniques and facilities for storing trainee relevant and unit relevant data for later analysis and administrative use.

The earlier mentioned definition of embedded training emphasizes equipment (i.e., built in, operational systems). One can then infer that instructional technology is a forgotten dimension. Indeed, our analysis of systems called embedded trainers, summarized in Table 1, shows that only a few trainers called "embedded trainers" have any instructional technology. Typically, the systems encountered are primarily signal generators or stimulators of some type, developed to present the exercises. This tendency is found to be true throughout the services. How will readiness be preserved in the absence of a major component of training, the instructor?

In reviewing the literature on instructor activities with respect to simulator based training, we found that a considerable portion of instructional activity is allocated to: creating, selecting, and modifying scenarios, monitoring trainee performance; simulating voice communications of missing personnel or teams; maneuvering platforms, modifying the sequence of exercises to provide scenarios which best develop trainee, subteam, or team weaknesses, and providing briefing and debriefing material. There is evidence to suggest that these kinds of activities may be provided automatically by incorporating expert systems technology and intelligent planning strategies to the course of instruction. Given the application of such technology to embedded training, the problem conditions which exist as a result of translating shore based training to embedded training can potentially be overcome. That is, those activities making up a major portion of instructor functions can be automated on board a platform.

Ageis Combat Training System (ACTS).
AN/TPQ-29 Improved Hawk Missile System (IHAWK).
AN/TSQ-73 Missile Minder Command and Control System(MMCCS).
Automatic Detection and Tracking Simulator (ADTSM).
Combat Control System MK-1 Training Mode.
Combat Team Operational Readiness Program (CTORP).
Carrier Air Control Center Shipboard Target Simulation System
Combat Simulation Test System (CSTS).
Electronic Counter Measures (ECM) Generator.
Guided Missile Simulator.
Guided Missile Training Round (GMTR).
In Flight Training (IFT) for F-14, AN/AWG-9.
Lesson Translator (L-TRAN) for NTDS.
LHD-1 Combat Simulation Test System (CSTS AN/SSQ-91).
On Board Simulation (OBS) for F-15.
On Board Electronic Warfare System (OBEWS).
On Board Trainer (OBT AN/SQS-T6).
Operational Readiness Assessment and Training System (ORATS).
Own Ship Motion Simulator (OSMOS).
OTS-V3R10 for AN/SLQ-32.
Performance Measuring Equipment (PME) for AN/SQQ-23.
Radar Recorder (RACOR).
Radar Video Recorder (RAVIR).
Radar Environmental Simulator System (RESS), AN/USQ-93.
Radar Proficiency Simulator (RPS).
Radar Video Simulator (RVS).
Radio Frequency Test Target Generator (RFTT).
Silverbox 2/WLR-1.
Submarine Operational Readiness Assessment and Training System.
Sonar Target Signal Simulator (STSS).
Simulated Target Training Program (STTP).
System Evaluator, Trainer SEAT.
Tactical Modular Display.
Tactical Proficiency Program (TPP).
Troop Proficiency Training (TPT).
Training Surface to Air Missile (TSAM).
Video Signals Simulator.
World Wide Military Command and Control System (WWMCCS)

Table 1. "Embedded Training" Systems Examined.

Fortunately, over the past ten years, technology has been implemented in various trainers which has automated some of the instructional and instructor support functions. These instructional technologies assist the instructor in conducting his activities during an exercise and, in some cases, perform an instructor's activities automatically. As several reviews have recently proposed, techniques for improving the modeling of instructor functions within the software of training systems are available employing techniques of cognitive science and artificial intelligence (Sullivan, Roth, Chinzoff & Bogner, 1986). It is, therefore, proposed that many of the problem conditions which emerge from embedding training, specifically as they relate to instructional activities, may be overcome by applying state-of-the-art software technologies.

Four technologies, specifically (1) adaptive computer-aided instruction, (2) automated expository feedback, (3) intelligent platforms, and (4) missing team member simulation, were chosen for further development and evaluation. Research and development was limited to these four based on our determination of criticality of need, resources available, maturity of hardware/software technology, and probability of success in developing technologies that can be quickly transitioned to a wide variety of operational systems under development.

Adaptive Computer Aided Instruction

Adaptive computer aided instruction allows the trainee to select the starting point for instruction and then assesses student strengths and weaknesses. This assessment is a continuous process. Once the system has determined initial strengths and weaknesses, it will automatically plan a course of instruction in order to present the student with exercises which best focus upon the students' specific strengths and weaknesses. During the course of this plan of instruction, the system also evaluates how rapidly the student is overcoming his weaknesses and whether or not specific strengths interact with new material in a deleterious way. The system, given this information through continuous assessment of student performance, can replan the course of instruction as needed. Consequently, the selection of exercises and the sequence or plan of exercises presented to the student is adapted to individual student strengths and weaknesses. These student plans can be saved and stored in memory so that later analysis can be conducted in order to identify any particular difficulties students are having when moving from less difficult to more difficult exercises. This information could then be used to modify the knowledge base of exercises at a later time. While numerous variations of this technology have been developed in intelligent tutor prototypes, it has not been tried, to date, in military ET systems.

Automated Expository Feedback

Automated expository feedback is a phrase which has been coined for this project. It applies primarily to rule utilization tasks as in decision making. The purpose of this form of feedback is to expose the error made on the part of the trainee by identifying specific preconditions which were not attended to or which were erroneously emphasized, consequently triggering inappropriate actions. This form of feedback employs expert systems technology and knowledge engineering techniques to simulate instructor actions by formulating a prescribed rule base for decisions and a search strategy to assess the application of specific decisions given a specific set of scenario conditions. The objective of this form of feedback is to promote the development of timely and accurate decision making within the constraints imposed by tactical doctrine.

Intelligent Platforms

Intelligent platforms serve to promote training by enhancing the realism with which targets maneuver in a scenario and by removing the requirement for an instructor to maneuver numerous targets within a scenario. These intelligent platforms are essentially expert system modules which test the states of the scenario and apply specific rules which are transferred into tactical actions. Incorporating these targets in exercises provides the trainee with greater realism in scenario conditions. Obviously the benefit of increased fidelity of trainer console interface is rendered worthless if the training scenarios do not provide comparable fidelity in terms of tactics displayed by targets in the training exercises. The skill level of targets can also be modified to vary the degree of difficulty of the scenario.

Missing Team Member Simulation

Missing team member simulation also involves the application of expert systems technology to training. This method removes the necessity for subteam members to actively participate in team training exercises, reducing the manpower requirement to conduct team training. More importantly, the application of this technology allows one to control the level of expertise of the simulated member(s). By doing so, specific criterion levels of performance can be maintained such that expectations on the part of the trainee participating in exercises can be directed toward high performance criteria. With each member of a team being trained in an environment with a common reference of expectations of other team member performance, team member performance in actual combat would be improved since all members would expect high criterion levels of performance. This is based upon empirical evidence which has demonstrated that team performance was highly dependent upon individual member expectations of other team member capabilities for communication and coordination tasks (Crowe, Hicklin, Kelly, Obermayer, & Sutzer, 1982). These tasks are the predominant activities of teams and subteams.

IV. STATUS AND PLANS

Having completed our review and analysis of the literature, and chosen the above-described technologies for further evaluations, we are currently (at the time of this writing) completing implementation of several intelligent platforms and a missing team simulation for preliminary evaluation. The evaluations are to be conducted on the command and control research testbed, currently housed in the Human Factors Division at the Naval Training Systems Center (NTSC). Evaluations of these technologies will begin during the summer of 1987, and results should be available for discussion at the time this paper is presented, in November 1987. Following evaluation of these capabilities, those technologies judged successful will be considered for modification, limited implementation and evaluation on the embedded training element of the

NAVAL TACTICAL DATA SYSTEM (NTDS), known as the Lesson Translator (L-TRAN). L-TRAN programs are currently supplied to over 150 major surface combatants and several shore-based schools from the L-TRAN Project Office at Fleet Combat Training Center, Pacific.

The adaptive computer-aided instructional module referred to above has also been designed and is under development by the University of Central Florida Institute for Simulation and Training (under contract with ONR and NTSC). A product of this task will be lesson design specifications to guide implementation of adaptive lessons for the L-TRAN. Based on these guidelines, experimental adaptive lessons will be written, in conjunction with the L-TRAN project office. These lessons will be debugged and a preliminary evaluation completed on an L-TRAN emulator housed at the Human Factors Division of NTSC, using Naval personnel from the various Service School Command schools in Orlando as subjects. Assuming a generally successful outcome from this evaluation, the adaptive strategies will be revised, implemented, and evaluated in a limited number of operational settings.

In summary, the instructional technologies defined above serve to automate many of the activities of an instructor and support personnel as well as provide additional realism to exercises. Given the emphasis upon fidelity as witnessed by the trend toward embedded training, it seems only consistent to provide more realism in terms of target maneuvers. Anticipated target maneuvers and tactics make up a major portion of what must be learned in tactical decision-making training. These technologies, although capable of being implemented, have not strictly been evaluated to determine their impact upon acquisition and retention of skills and knowledge. Since the instructional dimension is a significant component in the training equation, it is important to evaluate the impact of these technologies on what is learned, how rapidly learning takes place, and how well learned skills and knowledge are retained. Furthermore, by controlling the consistency of expertise of instruction by employing concepts such as expository feedback, transfer of expert information can be provided without the interference and inefficiency of learning by trial and error. This technology filters out bad instances in tactical decision-making and guides trainees along successful solution paths. The objective of this project effort is to both develop and evaluate the candidate instructional technologies described above.

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BIOGRAPHICAL SKETCH

Dr. Richard E. Reynolds is the technical team leader for Embedded Training and Command and Control Training in the Human Factors Division of the Naval Training Systems Center. As such he is responsible for coordinating all related projects within the division. He holds a Master's Degree and Ph.D. in Experimental Psychology from Miami University. He was formerly an associate professor of Psychology at Edinboro University of Pennsylvania. Dr. Reynolds has over 25 publications and presentations in the areas of Experimental Psychology and Human Factors.

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