IDENTIFICATION OF CRITICAL INSTRUCTIONAL SUPPORT FEATURES FOR EMBEDDED TRAINING IN THE SHIPBOARD ENVIRONMENT

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ABSTRACT

Embedded training has long been considered a potentially efficient training concept which could provide meaningful use of available time and resources to maintain skill proficiency levels or teach new skills while on the job. A major problem is the development of embedded training which can be used effectively by a single user and which will provide management and control of the training environment. Factors such as varying levels of training complexity and measurement of trainee performance are important training issues, and must be included in the training design. The Human Factors Division at Naval Training Systems Center is presently engaged in embedded training research using the AN/SPA-25G radar repeater as a test bed. The newly developed AN/SPA-25G radar display is a computer controlled console which can be used to automatically compute calculations such as intercept courses and speeds, closest points of approach and many other similar functions formerly requiring the use of maneuvering board procedures. This embedded training project is using the capabilities of the AN/SPA-25G radar repeater and innovative scenario generation software to develop both a training process and the necessary instructional support features which will deliver and manage the radar operator training onboard ship during routine operating hours. Training programs currently being developed include equipment proficiency training for newly assigned operators and for more experienced operators, task component training (practice of specific skills within a given task) either on the PC itself or on the AN/SPA-25G radar display, and scenario training with multiple targets.

The driving force behind the successful implementation of embedded training lies in the reduction of instructor workload while still providing quality training. One way that this can be accomplished is through a judicious application of key instructional support features. This paper discusses the methodology used in identifying 11 critical instructional support features necessary for successful embedded training in the AN/SPA-25G radar repeater and defines each of these important features.

INTRODUCTION

During deployment, Naval personnel are expected to maintain skill proficiency levels through on-the-job training (OJT). While OJT has been demonstrated to be a successful method for developing job-related skills in certain settings, the job environment is often not a good learning environment (Goldstein, 1986). In the Navy, the opportunity for OJT is often precluded due to shipboard constraints such as (1) high workload, and hence limited availability of qualified personnel who can fill the role of "onboard instructor;" (2) matching student availability with instructor, equipment, and "live" aircraft availability; and (3) operational commitments of equipment and personnel for mission requirements vice training needs. As a result of these limiting factors, maintaining certain high skill levels in a shipboard environment presents a formidable challenge.

The concept of embedded training (ET), has long been considered a promising solution to shipboard training problems. ET may be conceived of as a training capacity which is designed into an operational system. It has been defined by the Navy as "training that is provided by capabilities built into or added onto operational systems, subsystems, or equipment to enhance and maintain the skill proficiency of fleet personnel" (Department of the Navy, 1985). ET promises to reduce onboard instructor workload requirements, if training scenarios utilize sound instructional support features, and the training is integrally designed into the system. However, the features which make ET easy to use and a valuable training tool have rarely been designed into the system.

The Naval Training Systems Center (NAVTRASYSCEN) is currently engaged in a research program aimed at developing, implementing, and evaluating an ET capability within the Radar Display and Distribution System (RADDS). RADDS, which is being developed by the Naval Sea Systems Command (NAVSEASYSCOM), is composed of three major components: (1) the AN/SPA-25G radar repeater, (2) the SB-4229 switchboard, and (3) the CB 3989 converter. These three components incorporate state of the art radar display technology. The system is scheduled to be phased into the Navy over the next decade. The key component of this system is the AN/SPA-25G radar repeater, a solid state (except CRT) raster scan display that presents selected radar video from one of several basic radar systems. The AN/SPA-25G has six operational modes: Air Intercept Control (AIC), Navigation, Anti-Submarine Warfare (ASW), Anti-Surface Warfare (ASUW), Amphibious Assault, and Electronic Warfare (EW). The system is dramatically different from other non-Navy Tactical Data System (NTDS) radar repeaters in that the system software automates many of the computations traditionally performed by the operator (e.g., Closest Point of Approach, air intercept computations).

The ET research program is composed of several systematic steps which are intended to culminate in a self-contained training capacity within the RADDS. The intended training "packages" within this effort include equipment proficiency training, component skill training, and mission scenario training. The major components of this research effort include: (1) performing a training needs assessment in order to determine precisely what type of ET can make the greatest contribution; (2) identification of the critical instructional support features necessary to support ET; (3) development of scenario control software which will provide the means for creating training scenarios; (4) development of the real-time/play software which will execute the training software, track targets, and maintain performance records; (5) development and implementation of the equipment proficiency and component skill training; (6) development and implementation of training scenarios; and (7) evaluation of the ET capability. This paper focuses on one phase of this research effort: the identification of the critical instructional support features necessary to support ET within RADDS.

THE PROBLEM

As mentioned previously, shipboard constraints often inhibit the opportunity for hands-on practice, a critical component of OJT. Without this opportunity, the skill levels of operational personnel may rapidly decay. This is particularly troublesome when one considers that students may spend in excess of four months in formal school training only to discover limited opportunities to practice these newly acquired skills upon reporting aboard ship. This section will address some of these problems which interfere with the opportunity for hands-on training aboard ship.

Availability and Workload of Onboard "Instructors"

Deployment of a ship typically centers on a set of mission requirements. These requirements have top priority. As a result, training is often relegated to a lower level of priority. This is especially true of training for inexperienced personnel. Senior enlisted personnel are often a driving force in achieving mission goals and most of their duties are focused on these goals. Consequently, they have limited time to devote to the role of "onboard instructor". Without guided supervision from an experienced individual, inexperienced personnel may find themselves caught between the need for hands-on training and the lack of supervision for training. Even if available, the supervisor who is an expert on the system may not be qualified in instructional techniques or strategies necessary for proper training.

Student Availability

Even if the problem of onboard instructor availability could be resolved, a problem concerning student availability may emerge. Very often, new graduates reporting to their first duty station are assigned collateral duties (e.g., mess cooking) for up to six months. During this period, little effort may be devoted to practicing their previously acquired skills, and as a result, these skills may degrade rapidly (McDonald, 1984). The issue is compounded when one considers the difficulty in matching student availability with instructor availability and, can become even more severe by adding additional constraints such as availability of equipment and "live" targets to use for training.

Operational Tempo

A third problem area concerns the changing operational tempo associated with deployment. There are usually prolonged periods during which at-sea operations are fast-paced, hectic, and highly stressful--factors which are not conducive to structured learning activities featuring learning principles such as self-pacing, feedback and remediation. Furthermore, these operational factors may contribute an element of danger in a learning environment; for example, when the inexperienced radar operator provides an incorrect bearing and range to a target posing a navigational danger.

Equipment Design

Finally, operational equipment is designed to meet operational requirements. If training needs are considered at all in the design process, that consideration takes a secondary role. Consequently, when the equipment is to be used in a training function, limitations may arise. For example, in the case of a radar repeater, it is obvious that the primary goal is to display live aircraft, surface vessels, and landmass. However, when live aircraft and other targets are not present, nothing is displayed and very limited training (if any) can occur.

The use of equipment stimulation as a training tool has been used on some operational systems. For example, radar stimulators, which are designed to support system alignment and calibration (by displaying and checking synthetic targets with known ranges and bearings), have been adapted for use in training. Typically, these configurations fail to achieve their full training potential due to the lack of instructional features needed to support the training environment.

A potential solution for reducing problems encountered with shipboard training and lessening the reliance on nonstructured on-the-job training focuses on ET. By coupling radar stimulation technology with critical instructional support features, ET may reduce many of these shipboard constraints. For example, self contained training scenarios coupled with instructional support features such as augmented feedback, scenario initiation and control, and performance monitoring may serve to combat the problem associated with onboard instructor availability. Features such as replay/playback, recordkeeping, and performance measurement may contribute to reduced instructor workload. Additionally, the capability to display synthetic targets on the radar display via a target generator will lessen the reliance on "live" targets and will ensure that training is available at the students' convenience (e.g., after hours, slack time, etc.). The training can therefore occur without being impacted by the operational tempo and at a time when both the student and the equipment are available.

APPROACH TO PROBLEM RESOLUTION

In the shipboard environment, the typical scenario surrounding training activities includes the following: there are technicians who require training, supervisors who can, to some extent, guide the training activity, and limited availability of operational systems upon which to perform the training. The major problem is the coordination of these requirements and availabilities to accomplish meaningful training.

To fully understand how embedded training may be an effective solution to the problems of shipboard training, it is necessary to further examine the basic premise for a key element of ET - *instructional support features.* Instructional support features may be defined as characteristics of the equipment or trainer (hardware) which can be designed or programmed to control and/or present many elements of the training activity. They are important because they represent means to address two areas which may hinder effective training. These are instructor availability and the training technique or strategy employed. The significance of instructional support features in providing "programmed", structured and consistent training strategies is that their use can ensure control over the four essential components or steps inherent in the learning process. These learning components include the stimulus or cue (element to be solved or learned); the response (student reaction to the stimulus); the feedback (meaningful information concerning the appropriateness of the response); and the selection of the next activity (what the student should do next). These four aspects of the learning environment must be controlled by someone or something. All four ingredients must be present in the learning environment, regardless of who has control over them. Instructional support features are not capabilities that make learning easier, rather they are processes that are controlled by the equipment or trainer, which could be controlled by the instructor. Thus, instructional support features in the embedded training environment serve to reduce required instructor/supervisor time during training, facilitate the delivery of sound instructional strategies and provide the ability to measure the performance and track progress of the student.

Selection of the correct and necessary instructional support features requires a complete understanding of the operational environment into which the training procedures will be placed. Therefore, it was necessary to examine the activities of the operations specialist (OS) in the combat information center, how they utilized the AN/SPA-25G, what training they had received prior to shipboard duty, and that training necessary to remain proficient with the equipment. After this examination, the time requirements of the supervisors, along with the restriction and availability of trainee time and equipment had to be determined. Because instructional support features are designed to utilize the capabilities of the system that they support and to address the specific training requirements of the target environment, it is necessary to first examine and identify these elements to form the basis for the selection of the features and the development of the total embedded training package. Thus, the approach taken was to first determine the kind and type of embedded training to be done, identify those features of the environment which had to be augmented or controlled for successful training, specify the instructional feature characteristics of the training system necessary to support embedded training, and conduct a trade-off analysis which would help select the instructional support features and determine the complexity to which they should be developed. This analysis process was comprised of three initial steps: identify the basic type or area of training to be addressed, develop a list of potential instructional support features, and define the specific training requirements for which the features would be used. These three issues will be addressed in turn in the following paragraphs.

Type Of Training

The first step in the ET analysis was to identify the primary areas which training should address. This process began with the examination of three basic operator task areas. These were air intercept control (AIC), anti-submarine air control (ASAC) and navigation/piloting (NAV). The study of these basic tasks with subject matter experts (SMEs) supported the point-of-view that, contained within these tasks were training requirements in the areas of equipment, task and mission performance.

Further discussions with fleet SMEs and technical school instructors elaborated on these training requirements and resulted in three distinct training areas which were defined as follows:

- Equipment proficiency training - the maximum and correct use of the system for the task at hand. This was further defined by the SMEs as correct use of all operational capabilities of the system to achieve maximum usefulness in performance of the job. An example is the use of the Closest Point of Approach (CPA) function in track mode of the AN/SPA-25G radar repeater.

- Task component training - the mastery of one or more elements of a task. This means that a person should be able to practice a single critical part (or parts) of a task in isolation from the remainder of the task. An example of task component training is the practice of controlling a maneuvering aircraft during an ASAC problem task.

- *Mission Scenario training - refers to* the use of one or more complete tasks to create a scenario which reflects the activity of a person (or persons) in an actual operational environment. For example, controlling an interceptor from Combat Air Patrol (CAP) station to intercept and back to home base.

Each of these types of training should be designed to accommodate low to high entry level personnel.

Instructional Features

Once the above general areas were identified as training requirements, a list of potential instructional support features required to insure success in the embedded training environment was developed. Examination of reference documentation (Hritz, Harris, Smith and Purifoy, 1980) as well as historical data identified a large population of potential instructional support features to be considered for implementation. Generally defined, these features can be described in terms of four categorical types: monitoring instructional features, feedback instructional features, stimulus instructional features and miscellaneous features. This pool identified all possible features from which those most feasible would later be selected.

Training Requirements

The third step of the analysis entailed a critical examination of the specific training requirements for operational personnel. The methodology employed to define the training was a structured interview process during which the SMEs were questioned at length on critical factors, such as:

- Training requirements aboard ship - difficult training activities to accomplish, most training intense tasks, proficiency training needs, significant training needs, most often performed tasks.
- Radar display requirements - what are critical radar characteristics to replicate in training, what needs to be most frequently replicated from the actual environment.
- Fidelity issues - what are distinctive targets, accuracy of displays, reality aspects of environment.
- Criticality issues - what is essential to job performance, impact of tasks if poorly done, what training is not done due to safety considerations.
- Environmental issues - availability of supervisory help, performance measurement considerations, availability of training time, equipment availability.

These and other related questions were the catalysts to data collection interviews with shipboard, staff and technical school operations specialists. The results of these discussions led to the conclusions that for embedded training to be successful, supervisor's time to manage training must be minimized, training performance must be measured and improvement recorded over time, and the features required should have minimal impact on equipment. In addition, the issue of cost was deemed a critical consideration, particularly in the design specifications describing the complexity of the features, e.g.: use of sound powered phone circuits for practicing communication procedures versus the use of interactive voice recognition and digital voice generation to simulate a communications circuit.

The preceding three step analysis process and the resultant issues identified provided the basis for an initial selection of the most appropriate instructional support features. Based on the analysis, seventeen (17) features were chosen as those which were most acceptable and which should be further examined to provide for support of ET. These features are as follows:

- Scenario Control - this feature is to be software containing actual preprogrammed scenarios which are to be linked to the target generator which, in turn, sends appropriate signals to the AN/SPA-25G replicating the actual environment.
- Student/Instructor Cueing - visual cues consist of various messages which are either printed on the screen in graphics for help or information or are presented in the form of lights or buttons flashed on and off. Audio cues are directions such as those directing one to track or initiate intercepts and can be verbal when the scenario is initiated.
- Target Control - In the operational environment, targets or ownship must respond to the operators' direction or recommendation. Thus, in ET, the target will have to be programmed to follow the trainee recommendations for Course/Speed changes.
- Signal-To-Noise Ratios - In the operational environment, the operator has to contend with static or noise in both visual and audio cues. This feature can replicate "noise" which can be controllable by programmed scenario difficulty.
- Record Keeping - this feature stores the trainee's performance scores (by name, date, and SSN) and maintains a history of accomplishment for each trainee.
- Voice Recognition - for this feature, the computer is programmed to recognize a student's voice and accept it as the only voice to respond to. When these commands are accepted, the computer directs the designated target to do as instructed by the student.
- Voice Synthesis - in this feature, the computer generates a voice to represent the responding (of a target) to the verbal commands of the student.
- Performance Measurement - this feature senses all of students actions, compares them to a standard and develops a performance profile during the exercise.
- Verbal Recording - this feature stores all voice communication within each scenario.
- System Monitor - this feature (coupled with the ability to sense all student actions) evaluates those actions and provides feedback regarding the appropriateness of the action.

- Sign In - this feature records the time the student initiated the training activity and records all data regarding performance in that students name.

- Freeze Action - this feature alerts either the trainee or the instructor when the trainee makes a response that is so far off proficiency as to require special help.

- Replay/Playback - this feature is the ability to replay entire scenarios including the student's actions previously recorded.

- Fast/Slow Time - this feature enables the speeding up or slowing down of a problem or scenario so as to limit non-productive wait time. This feature can also be used to reduce the time it takes to replay an exercise.

- Reporting Devices - this feature is a device which can print a copy or present on a video screen the recorded student actions or scores.

- Feedback - this feature provides performance information (knowledge of results) to the student after the completion of a scenario. This feature provides the student with information concerning the correctness of the student's responses. This information is then used by the instructor as a key element in the presentation of augmented feedback: information concerning how or why responses were incorrect and how to improve performance.

- Rate Control Adjustment - this feature controls the rate and quantity of scenario cues which are presented to students. This feature can alter complexity and/or difficulty by increasing or decreasing the number or presentation rate of scenario elements such as landmass obstacles, targets, and environmental conditions.

Trade Off Analysis

Once the instructional support features were identified, it was necessary to evaluate each one based on fixed criteria and compare them to the various types of training required: equipment proficiency, task component and mission scenario. Features were evaluated by the following criteria for each training type:

- Cost of feature - this was described in relative cost terms when compared at various levels of complexity for each feature.

- Fidelity - degree of reality when compared to the actual system.

- User acceptance - an estimate by SMEs of how well the feature or change would be accepted in the operational environment.

- Training effectiveness - an estimate of the positive impact of the feature on the training environment.

The above evaluation of the features was further refined according to their absolute requirement in the training environment. They were placed in one of four categories:

- Required for embedded training - without which training cannot occur.

- Will minimize supervision - if used, the supervisor's time will be reduced, but training can occur without.

- Desired but not necessary - does not have a significant effect on either supervision or training, but would be an assist to the trainer.

- Nice to have - not needed, but would provide some attractive features.

The result of these exercises was a list of features which were rated highest in comparison to criteria and which were either required for training or minimized supervision. These eleven instructional support features were: Target Control, Freeze Action, Replay/Playback, Scenario Control, Feedback, Record keeping, Performance Measurement, Sign-In, Student/Instructor Cueing, System Monitor, and Signal-To-Noise Ratios. These eleven features are judged most likely to ensure success of embedded training on the AN/SPA-25G radar repeater.

CONCLUSIONS

Successful embedded training requires the judicious use of instructional support features to ensure the ease of use and the adequate training control necessary in the operational environment. This design is required due to limited training time, equipment and supervision. Embedded training for the AN/SPA-25G radar repeater must include software/hardware for implementation of these important system features.

Each of these critical instructional features will be considered in the next phase of this research effort - the development and implementation of ET scenarios. While these critical instructional features were determined via a systematic approach, and tapped the knowledge of SMEs, little or no empirical data concerning their contribution to the training function exists. Only through carefully controlled evaluations can the validity of these features be judged.

REFERENCES

Department of the Navy. Memorandum by the Chief of Naval Education and Training, Report on Embedded Training for Flag-Level Steering Group, Pensacola, FL, (November, 1985).

Goldstein, I.L. Training in Organizations: Needs Assessment, Development, and Evaluation. Belmont, CA: Brooks Cole, (1986).

McDonald, L.B. Passive Acoustic Analysis Training Problems, NAVTRAEQUIPCEN Technical

Report 83-M-0844-2, Orlando, FL: Naval Training Systems Center, (1984).

Hritz, R.J., Harris, H.J., Smith, J.A., and Purifoy, G. R. Maintenance Training Simulator Design and Acquisition - Handbook of ISD Procedures for Design and Documentation. Valencia, Pennsylvania: Applied Sciences Associates, (F33615-78-C-0019), (1980).

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