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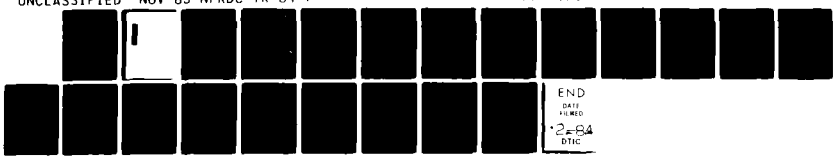

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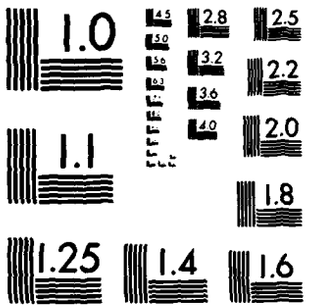

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ESTIMATING SKILL LOSS THROUGHOUT A NAVY TECHNICAL TRAINING PIPELINE

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The objective of this effort was to determine how training conditions in follow-on schools in the training pipeline for aviation antisubmarine warfare operators (AWs) assigned to S-3A aircraft affect acoustic analysis skills acquired early in the pipeline. Subject matter experts at follow-on schools were interviewed to obtain qualitative information about the amount of practice, feedback, and lengths of task nonutilization periods for acoustic analysis for four training periods. Also, knowledge and performance tests were administered at four points in training to 154 AW S-3A students

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assigned to the schools. Interview results showed that there was a likelihood of serious skill degradation potential for three of the four periods of time analyzed. Also, significant differences were found for the effects of time in training on knowledge and performance test scores. Students performed poorest at test point 1, following 2 months of task nonutilization while in transit from AIT school, and best at test point 2, immediately following training at Common Core. Student scores showed substantial decline at test points 3 and 4, while they were in operator training.

FOREWORD

This research and development was performed in response to recognized Navy needs for an investigation of the effects of initial training and job conditions on skill retention under subproject RF63-522-001-010 (Computer-aided and Classroom Training), work unit 03.03 (Skill and Knowledge Retention). The objectives of this subproject are to (1) derive ways of detecting potential skill retention problems in the Navy and (2) recommend means to minimize performance deterioration by restructuring training and job conditions.

This is the tenth report concerned with skill deterioration. Previous reports described long-term retention of factual information in the Propulsion Engineering Basics Course, the effects of different instructional strategies on long-term retention of materials taken from that course, existing research relevant to skill and knowledge loss, a survey of the three Navy sonar communities--aviation, subsurface, and surface, assessments of job and training variables leading to skill loss in sonar technicians (surface) (STGs) and aviation antisubmarine warfare operators (AWs), skill deterioration in the AW training pipeline due to nonutilization, the effects of display format on sonar operator performance, and assessment of an operator training course (NPRDC TN 80-5, TR 81-22, and SRs 82-21, 83-18, 83-26, 83-28, 83-31, 83-37, and 83-53).

The objective of the effort described herein was to determine whether loss of skills and knowledge required to perform complex tasks could be estimated by assessing the quality of training conditions provided throughout the training pipeline. Results are intended primarily for the Anti-Submarine Warfare Wing, Pacific, the Fleet Aviation Specialized Operational Training Group, Pacific (FASOTRAGRUPAC), and for other agencies concerned with passive acoustic sonar operator training and testing. This report should also be of interest to agencies responsible for the development of skill acquisition and maintenance programs for personnel in other technical ratings.

Appreciation is expressed to the members of the instructor staff at FASOTRAGRUPAC AW Common Core Acoustic Analysis Course and the Fleet Replacement Squadron (FRS) (VS-41) operator course, Naval Air Station, North Island, for their time and efforts in collecting material for this report.

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SUMMARY

Problem

Technical training in many Navy ratings is provided in a series of schools (training pipeline). Often, training for a critical rating skill occurs early in the pipeline, with very limited provision for practice or review of that skill in the follow-on schools. Thus, that skill is likely to be degraded, particularly if students are concentrating on learning other difficult and unrelated skills. Using direct performance measures to determine those points in the training pipeline where skill loss is likely to occur is expensive, difficult, and time consuming. An indirect method of determining those points needs to be developed.

Objective

The purpose of this effort was to determine how training conditions in follow-on schools in the training pipeline for aviation antisubmarine warfare operators (AWs) assigned to S-3A aircraft affect acoustic analysis skills acquired early in the pipeline.

Approach

Subject matter experts at the Fleet Aviation Specialized Operational Training Group, Pacific (FASOTRAGRUPAC) AW Common Core Acoustic Analysis School and the Fleet Replacement Squadron (FRS) (VS-41) were interviewed to obtain qualitative information about the amount of practice, feedback, and lengths of periods of task nonutilization for acoustic analysis for four periods of training in the AW S-3A training pipeline. Interview results were used to make estimates about the likelihood of skill loss during these periods.

Knowledge and performance tests were administered at four points in training to 154 AW S-3A students assigned to FASOTRAGRUPAC Common Core and FRS (VS-41). The knowledge test was a multiple-choice test consisting of factual (theory and acoustic intelligence parameters) and computational (equations and acoustic intelligence plus equations) items. The performance test measured student performance of acoustic analysis (sound source, propulsion mode) and classification (threat, type, prime mover) skills on five static linear lofargrams.

Results

The quality of the skill maintenance conditions in the AW S-3A training pipeline indicated serious skill degradation potential for three of the four periods of time analyzed. Poor conditions for practice and feedback, with long periods of task nonutilization for acoustic analysis skills were found for period 1 (2-month transit period between AW "A" School and the beginning of Common Core), period 3 (equipment familiarization at FRS (VS-41)), and period 4 (crew integration and flight duty segments at FRS (VS-41)). Good conditions were found for period 2 (Common Core).

Significant differences were found for the effects of time in training on knowledge and performance test scores. Students performed poorest at test point 1, following 2 months of task nonutilization while in transit from "A" school, and best at test point 2, immediately following training at Common Core. Student scores showed substantial decline at test points 3 and 4, while they were in operator training at FRS (VS-41).

Conclusions

1. Assessing the amount and quality of practice, feedback, and lengths of task nonutilization periods occurring in follow-on training appears to provide a good estimate of the likelihood of skill and knowledge degradation of earlier learned skills.

2. If newly trained acoustic analysts are not provided with adequate practice and explicit feedback, their skills and knowledge are subject to substantial degradation within a relatively short period (1 to 3 months).

3. Task-specific practice, explicit performance feedback, and constant task utilization of complex skills such as acoustic analysis would probably ensure good retention of those skills. However, these conditions may be difficult to provide while a student is assigned to a follow-on school. The quality of initial training should be investigated to determine if instructional methods could be developed that would enhance retention of complex skills under less than optimum conditions.

Recommendations

It is recommended that:

1. Training managers determine if skills acquired early in pipeline training are adequately maintained during additional training by assessing the amount and quality of practice, feedback, and the lengths of task nonutilization periods occurring in the various follow-on schools.

2. FRS (VS-41) instructors provide students in operator training additional practice in acoustic analysis and explicit feedback about their performance to help them better maintain those skills.

3. Research be conducted to determine if retention of complex tasks is influenced by type of instruction.

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INTRODUCTION

Problem

Technical personnel in many Navy ratings are extensively trained in a number of diverse job skills in a series of schools (training pipeline) before being sent to the fleet. Each school in the training pipeline is responsible for teaching the skills and knowledge related to a specific subject area required by the technical rating. Students often are trained for a critical rating skill early in the pipeline and find that the follow-on schools provides limited opportunity for practice in and review of that specific skill. Thus, that skill is likely to be degraded, particularly if students are concentrating on learning other difficult and unrelated skills. Using direct performance measures to determine those points in the training pipeline where skill and knowledge loss is likely to occur is expensive, difficult, and time-consuming. An indirect method of determining those points needs to be developed.

Background

Recent findings in the literature suggest that students need frequent practice with critical feedback and a minimization of task nonutilization to preclude loss of acquired skills and knowledge (Hurlock & Montague, 1982). The more cognitively complex the skill, the better the practice, feedback, and task utilization must be to assure skill and knowledge retention. If the amount or quality of one or more of these variables is reduced, skills required to perform complex tasks correctly may be degraded. In Navy technical ratings, the loss of critical skills may seriously affect the quality of newly trained operators and ultimately affect mission readiness.

Wetzel and Montague (1983) surveyed three Navy sonar communities--aviation, subsurface, and surface--to determine conditions leading to skill and knowledge loss. They identified three job condition variables--practice, feedback, and length of task nonutilization periods--all of which varied among the three Navy sonar ratings--sonar technician (surface) (STGs), sonar technician (submarine) (STS), and aviation antisubmarine warfare operator (AW). Because of the poor job conditions for STGs, it was predicted that they would perform poorly on critical rating tasks. On the other hand, because of job conditions that adequately supported acoustic analysis skills and knowledge, it was predicted that AWs would perform well on tests of those skills. These predictions were confirmed by testing performance of STGs and AWs (Wetzel, Konoske, & Montague, 1983a; Konoske, Wetzel, & Montague, 1983).

In addition to predicting skill and knowledge loss based on job conditions, it should also be possible to estimate where skill degradation occurs in pipeline training by assessing the quality of skill maintenance conditions provided during that training period. This could be accomplished by determining (1) the point in a pipeline when a critical skill is initially acquired, (2) the amount of practice and the quality of feedback provided students to help maintain that skill during the training of unrelated job skills, and (3) the lengths of the periods during the pipeline when the skill is not used.

AWs can be assigned to three aviation platforms: VP (patrol, P-3 aircraft), VS (sea-based, S-3A aircraft), and HS/HSL (sea-based helicopter). Those in the AW S-3A Pacific training pipeline spend about 3 weeks in initial training in basic acoustic analysis procedures at the AW "A" School and 4 weeks at the Fleet Aviation Specialized Operational Training Group, Pacific (FASOTRAGRUPAC). These 4 weeks are spent in the AW Common Core Acoustic Analysis Course, which provides additional analysis

training plus acoustic intelligence data to enable the student to classify acoustic targets. Finally, they attend a 16-week school at the Fleet Replacement Squadron (FRS) (VS-41) to receive operator and air crew training. For AWs, the training emphasizes use of equipments specific to S-3A platform requirements, air crew coordination, and operational flight duties and provides only limited training in analysis skills, acoustic intelligence parameters, and target classification.

This pipeline is organized such that AWs acquire the critical rating skill of acoustic analysis and classification in the initial half of training. However, since they have little opportunity for practice/feedback in the second half of training and face a long period of task nonutilization, it is likely that their acoustic analysis and classification skills will degrade substantially by the end of FRS (VS-41).

Objective

The objective of this effort was to determine how training conditions in follow-on schools in the AW S-3A training pipeline affected acoustic analysis skills and knowledge acquired early in the pipeline. Wetzel, Konoske, and Montague (1983b) showed a significant loss of skill and knowledge over the 24-day task nonutilization period between the basic acoustic analysis course and the follow-on operator course. Evidence that there are other points in the pipeline that would lead to skill and knowledge loss prompted a more extensive investigation.

APPROACH

Subjects

Subjects were a cross-section of 154 S-3A AWs who were assigned to the Common Core Acoustic Analysis School and the FRS (VS-41) based at the Naval Air Station, North Island. All had attended the AW "A" School within 4 months of entering Common Core. Those who had had previous experience in acoustic analysis (i.e., other Navy sonar rating, other AW platform) were excluded from the sample.

Procedure

Subject matter experts (SMEs) from instructor staffs at Common Core and FRS (VS-41) were interviewed to obtain qualitative information about the amount of practice, quality of feedback, and lengths of task nonutilization periods for acoustic analysis in the AW S-3A pipeline. Results were used to estimate whether skills and knowledge loss would occur during the following periods:

1. The time between graduation from AW "A" School and the first day of instruction at Common Core (approximately 2 months).

2. The time spent in training at Common Core (approximately 1 month).

3. The time between graduation from Common Core and the first day of FRS (VS-41) Unit 4, OL-82 simulator training (approximately 1 month).

4. The time between graduation from Unit 4 and the end of operator training at FRS (VS-41) (approximately 3 months).

Also, subjects were administered an acoustic analysis knowledge test and a static Lofargram analysis and classification test at four points in their training corresponding to the four time periods analyzed; that is, students took the tests before they (1) commenced training at Common Core (Week 1), (2) graduated from Common Core (Week 4), (3) commenced OL-82 sonar simulator training (Unit 4) at FRS (VS-41) (Week 8), and (4) graduated from FRS (VS-41) operator school (Week 20). At each point, students were administered the knowledge test prior to the performance test. They were allowed to use hand-held calculators on both types of tests and mechanical dividers (10 points) on the performance tests.

Performance Measures

The knowledge tests consisted of multiple-choice questions that required the students to answer factual and computational questions. The factual questions concerned either theory (i.e., physics of sound, oceanography) or acoustic intelligence parameters for specific target types. The computational questions required the student either to select appropriate equations to solve a stated test problem, or to select approximate equations and recall specific acoustic intelligence parameters to solve the problem. Three alternate forms of the knowledge test were developed. Tests were reviewed by subject matter experts and equated for difficulty.

The acoustic analysis and classification tests consisted of five static linear lofargrams equated for level of difficulty between tests. The student was required to (1) analyze the gram by correctly identifying sound sources and propulsion mode and (2) classify the target in terms of threat, type, and prime mover.

Design

A one-way between-groups analysis of variance (ANOVA) design, with the point in training as the independent variable, was used. Dependent measures were (1) scores obtained on the total knowledge tests, with subpart scores on items specific to theory, acoustic intelligence parameters, computation, and computation plus acoustic intelligence parameters, and (2) scores obtained on the gram analysis and classification tests, including the analysis measures of identification of sound sources and propulsion mode as well as classification scores on classification accuracy and threat, type, and prime mover identification. All measures of acoustic analysis knowledge and performance were obtained for 50 subjects at test point 1, 50 subjects at test point 2, 20 subjects at test point 3, and 34 subjects at test point 4.

RESULTS

Interview Results

Table 1, which provides results of SME interviews, shows that the training conditions in three of the four training periods analyzed were rated as "poor," thus indicating serious skill degradation potential.

Table 1

Training Conditions for the Maintenance of Acoustic Analysis Skills and Knowledge at Four Periods in the AW Pipeline

Training Period	Content of Training	Amount of Practice	Amount of Feedback	Length of Nonutilization Periods	Estimated Quality of Training Conditions
1	--[a]	--[a]	--[a]	8 weeks	Poor
2	Acoustic analysis	Daily	Daily	0	Good
3	Acoustic equipment familiarity	None	None	4 weeks	Poor
4	Acoustic equipment operation and crew integration	Infrequent	Infrequent	12 weeks	Poor

[a]During this period, students are in transit, waiting for class to begin, etc.

The four periods are described in the following paragraphs.

1. Period 1. The training conditions for Period 1 were uniformly poor for maintenance of the skills and knowledge gained at AW "A" School. During this period, students are in transit to FASOTRAGRUPAC, waiting for the scheduled acoustic analysis class to begin, or fulfilling other rating requirements (i.e., Survival School). There is no opportunity for them to review or practice skills and knowledge specific to acoustic analysis. Because of the classified status of the subject material, students do not have notes, workbooks, or practice grams in their possession. Due to the lengthy task nonutilization period (8 weeks), it is estimated that a serious loss of skills and knowledge will occur at this point in the training pipeline.

2. Period 2. The training conditions for Period 2 are generally very good. The Common Core curriculum specifically addresses the skills and knowledge needed to perform acoustic analysis. Every day, students attend lectures that provide instruction on the tested topics and receive practice in gram labs that allows hands-on application of skills gained in the course, as well as feedback from instructors concerning their performance on acoustic analysis and classification tasks. There are no long task nonutilization periods for acoustic analysis and classification skills. Although the topic-oriented structure of the course does not provide for constant review and integration of topic information taught early in the course, these topics are reviewed prior to the final test in a course review segment. Because of the training conditions during this period, it is predicted that students will perform well on tests that measure recognition of factual items and skills of acoustic analysis and classification.

3. Period 3. The training conditions in Period 3 do not provide students an opportunity to practice acoustic analysis knowledge and skills. The focus of training during this period is on equipment familiarity, commonly known as "buttonology."

Students are not required to demonstrate knowledge of oceanography, physics of sound, sound source identification, acoustic analysis, or classification techniques. Thus, the entire month is essentially a task nonutilization period for acoustic analysis. Because of these training conditions, substantial loss of acoustic analysis and classification skills is predicted, as well as loss of factual knowledge bases.

4. Period 4. The training conditions in Period 4 provide students with little opportunity for comprehensive practice of acoustic analysis skills and knowledge. Although students spend a limited amount of time on tasks when they are learning to operate the OL-82 sonar system simulator and using the S-3A integrated crew trainer, the focus is on proper equipment operation and aircrew integration, rather than on maintaining or improving acoustic analysis skills. Due to the emphasis of instruction, students receive relatively little feedback as to the quality of their performance as analysts. Instead, feedback is directed towards their ability to operate equipment and to perform with other aircrew members. There are no objectives in this course that require the student to demonstrate an ability to analyze and classify a lofargram or their knowledge of oceanography, physics of sound, sound source identification, or acoustic intelligence parameters other than indirectly when operating the equipment. Because most of the time spent in this course is concentrated on acquiring and perfecting skills other than acoustic analysis, there is a long period of task nonutilization. Because of the quality of the skill maintenance conditions provided in this training period, a serious loss of factual knowledge and substantially poorer performance on acoustic analysis/classification performance tests is predicted.

Performance Measures

Tables 2 and 3, which present results of the ANOVAs performed on the knowledge and performance test scores obtained at four points during training, show significant differences on all parts of both tests. Table 4 presents mean percentages and standard deviations (SDs) on the tests at the four points in training. Finally, Figures 1 and 2 show the trend in test performance at the four points in training. Students performed the worst at test point 1, following 2 months of skill nonutilization while in transit from "A" school, and the best at test point 2, immediately following training in acoustic analysis at Common Core. Performance declined substantially while the students were in operator training at test points 3 and 4. The results of both tests follow the same general pattern except that the scores on the knowledge test computation and computation plus intelligence items deviated slightly (scores at period 4 are higher than those at period 3), probably due to the small number of those types of test items. These results show that student performance degraded significantly while they were in operator training at FRS (VS-41).

Table 2

Summary Tables for Five One-way ANOVAS for the Effects of Point in Training on Knowledge Test Total Scores and Subtest Scores

Source	df	MS	F
TOTAL KNOWLEDGE TEST			
POINT IN TRAINING	3	19555.74	188.60*
Error	150	103.68	
THEORY ITEMS (SUBTEST)			
POINT IN TRAINING	3	18243.64	67.79*
Error	150	269.10	
INTELLIGENCE ITEMS (SUBTEST)			
POINT IN TRAINING	3	22709.25	137.09*
Error	150	165.65	
COMPUTATION ITEMS (SUBTEST)			
POINT IN TRAINING	3	11760.14	18.07*
Error	150	650.78	
COMPUTATION & INTELLIGENCE ITEMS (SUBTEST)			
POINT IN TRAINING	3	33745.10	148.66*
Error	150	226.99	

*$p < .01$.

Table 3

Summary Tables for Six One-way ANOVAS for the Effects of Point in Training on Gram Analysis and Classification Test Scores

Source	df	MS	F
GRAM ANALYSIS TEST:			
1. Sound source identification			
Point in training	3	21464.00	44.71*
Error	150	479.99	
2. Propeller mode identification			
Point in training	3	38934.50	70.18*
Error	150	554.77	
GRAM CLASSIFICATION TEST:			
1. Correct classification			
Point in training	3	33138.51	67.00*
Error	150	494.56	
2. Threat identification			
Point in training	3	21293.88	49.86*
Error	150	427.03	
3. Type identification			
Time in training	3	26962.66	61.41*
Error	150	439.05	
4. Prime mover identification			
Point in training	3	22612.89	53.94*
Error	150	419.21	

*$p < .01$.

Table 4

Mean Percentages and Standard Deviations for Test Scores at Four Points in Training

Source	Training Point 1 (N=50)	2 (N=50)	3 (N=20)	4 (N=34)
Knowledge Tests				
Total test				
Mean	35.80	83.34	69.80	65.26
SD	11.32	7.35	13.67	9.63
Theory items				
Mean	58.02	92.50	89.00	48.82
SD	18.66	11.57	16.51	18.71
Intelligence items				
Mean	31.50	81.28	73.75	65.88
SD	14.42	12.44	12.57	11.08
Computation items				
Mean	48.96	83.06	74.75	81.11
SD	29.45	20.74	28.53	23.70
Computation & Intelligence items				
Mean	20.80	80.66	51.50	71.82
SD	15.09	12.47	17.25	17.05
Performance Tests				
Gram Analysis:				
Sound source identification				
Mean	23.38	70.36	67.00	40.58
SD	22.53	22.54	20.79	20.58
Propulsion mode identification				
Mean	17.78	81.80	58.00	28.82
SD	23.66	23.42	23.30	23.71
Gram Classification:				
Correct classification				
Mean	29.45	84.43	75.00	34.70
SD	26.28	17.70	22.36	21.63
Threat identification				
Mean	51.40	96.60	83.00	54.70
SD	28.16	6.86	18.66	21.18
Type identification				
Mean	38.04	86.80	81.00	41.17
SD	27.78	14.90	17.74	18.38
Prime mover identification				
Mean	51.66	94.58	91.00	51.17
SD	27.21	12.49	13.72	21.56

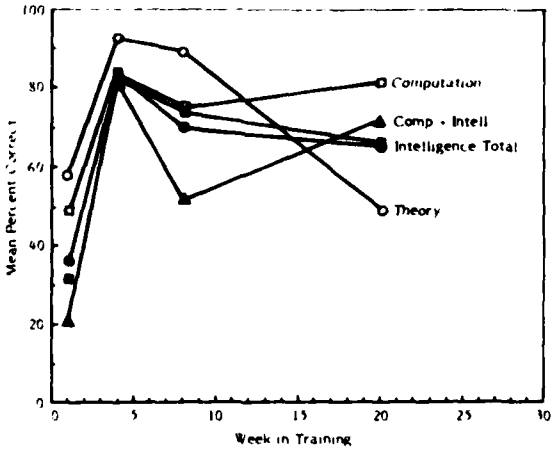
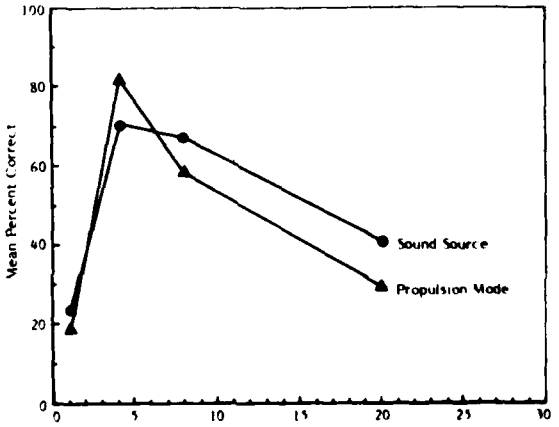
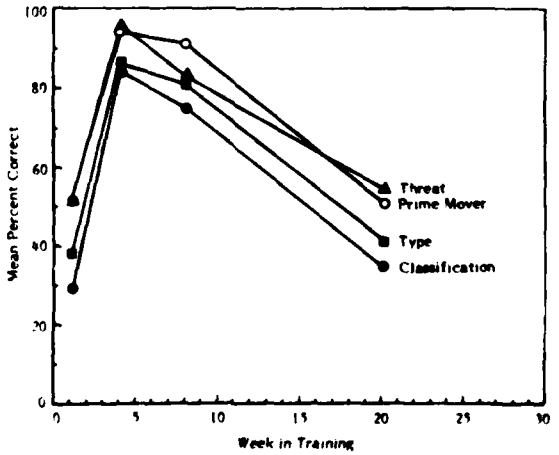


Figure 1. Mean percent correct on knowledge tests given at four points in training.



a. Gram analysis.



b. Gram classification.

Figure 2. Mean percent correct on performance tests given at four points.

DISCUSSION

The results of this effort show that the amount and quality of practice, feedback, and task utilization conditions provided the student during each training period can be used to estimate the level of performance on the knowledge and gram performance tests following each of those training periods. These results are consistent with the results of earlier research using the quality of job conditions to estimate the likelihood of skill and knowledge degradation. When practice, feedback, and task utilization conditions are good, the performance for that period is good. When they are not, the skills and knowledge needed to perform will degrade significantly.

In the AW S-3A pipeline, students are taught the fundamentals of lofargram analysis in the AW "A" school. Following that training, a period of about 2 months of task nonutilization occurs prior to additional training at Common Core. Since this effort did not obtain test scores for subject students before they graduated from "A" school, it is impossible to report specific amounts of skill and knowledge degraded during this period. However, their poor performance on both the knowledge and the gram performance at test point 1 is not surprising, given the poor skill maintenance conditions provided during the interim period. In contrast, high levels of practice, feedback, and task utilization were provided in the 4 weeks of training at Common Core. The quality of these conditions is consistent with the students' high performance on the knowledge and gram tests at the end of that course. The next two points of testing occurred during and at the end of the FRS (VS-41) operator school, where explicit practice of acoustic analysis and classification skills, individual performance feedback, and task utilization conditions were relatively poor. As a result, student performance on the knowledge and gram tests following those periods was poor when compared to that achieved at the end of Common Core.

Following FRS (VS-41) operator training, the newly trained AW reports to a fleet S-3A squadron. Although this effort did not test operators at that point, SMEs reported that there would be a task nonutilization period ranging from 1 to 3 months while the operator was in transit or assigned to other duties. That period should further degrade the skills and knowledge needed by the operator to perform acoustic analysis and classification.

This effort primarily addressed the need for maintaining skills and knowledge acquired early in pipeline training by providing students with adequate practice, feedback, and task utilization. Clearly, there is a need to provide additional practice of these skills and to allow time to review the knowledge factors required to perform the task. However, other issues, such as the quality of initial training, may influence the retention periods for complex knowledge and skills. For example, retention of skills and knowledge may be enhanced by better structuring of complex information, by teaching clear conceptual models of the task, and by providing students with explicit diagnostic feedback about their performance.

CONCLUSIONS

1. Assessing the amount and quality of practice, feedback, and lengths of task nonutilization periods occurring in follow-on training appears to provide a good estimate of the likelihood of skill and knowledge degradation of earlier learned skills.

2. If newly trained acoustic analysts are not provided with adequate practice and explicit feedback, their skills and knowledge are subject to substantial degradation within a relatively short period (1 to 3 months).

3. Task-specific practice, explicit performance feedback, and constant task utilization of complex skills such as acoustic analysis would probably ensure good retention of those skills. However, these conditions may be difficult to provide while a student is assigned to a follow-on school. The quality of initial training should be investivated to determine if instructional methods could be developed that would enhance retention of complex skills under less than optimum conditions.

RECOMMENDATIONS

It is recommended that:

1. Training managers determine if skills acquired early in pipeline training are adequately maintained during additional training by assessing the amount and quality of practice, feedback, and the lengths of task nonutilization periods occurring in the various follow-on schools.

2. FRS (VS-41) instructors provide students in operator training additional practice in acoustic analysis and explicit feedback about their performance to better maintain those skills.

3. Research be conducted to determine if retention of complex tasks is influenced by type of instruction.

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