NONRESIDENT COMPUTER-BASED TRAINING: EFFECTIVENESS EVALUATION

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ABSTRACT

The effectiveness of conducting computer-based training (CBT) at Coast Guard duty stations was determined in an experiment, comparing 3 training delivery approaches: 1) nonresident CBT course conducted at students' duty stations; 2) resident CBT course (the same course) conducted at a training center; and 3) traditional resident instructor-led course conducted at a training center. The existing 1-week AN/WSC-3 UHF transceiver maintenance course was selected for the evaluation, with the CBT version developed by an independent contractor. Training effectiveness was determined using several measures, including student hands-on performance during the troubleshooting and repair of actual malfunctioning transceivers, pre- and post-training knowledge tests, and student reactions to the training. The nonresident CBT course conducted at duty stations was found to be as effective as the instructor-led resident course, and required substantially less training time. Follow-up interviews conducted with a subset of the participating duty stations found that students, commanders and other staff strongly support the implementation of nonresident training. They also found that staff were concerned about how nonresident CBT would be implemented; important issues and potential obstacles were identified. A cost analysis uncovered trade-offs between resident instructor-led and nonresident CBT courses, and found that nonresident CBT provided to students at duty stations can save training dollars.

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INTRODUCTION

Training cost reduction, while maintaining effectiveness, is of concern to many federal government organizations. Computer-based training (CBT) and other training technologies provide opportunities to re-structure the training system, and achieve substantial cost-effectiveness gains. The U.S. Coast Guard Research and Development Center has been investigating the viability of using advanced training technologies to train personnel at their duty stations (e.g., on cutters and at shore stations). Nonresident training conducted at duty stations has several potential benefits in addition to reduced costs, such as reduced student training time, and increased flexibility for the duty station in meeting their operations and training needs.

The study objective was to determine the feasibility of conducting nonresident training at U.S. Coast Guard (USCG) duty stations. It consisted of 3 parts:

1. **Training effectiveness** - An experiment was conducted to evaluate the potential effectiveness of nonresident training (Hammell and Kingsley, 1998).

2. **Implementation issues** - Information was collected from interviews at duty stations to identify issues that must be addressed to implement effective nonresident training (Hammell, et al, 1998);

3. **Cost comparison** - A cost analysis of nonresident CBT was conducted (Kingsley, Cummings and Hammell, 1998).

This paper presents the study results, addressing each of the 3 parts.

TRAINING EFFECTIVENESS

Methodology

The potential effectiveness of nonresident training was investigated in an experiment, training USCG Electronic Technicians (ET) to troubleshoot and maintain the AN/WSC-3 UHF transceiver (a rack-mounted transmit/receive radio used by USCG and Navy units). A CBT version of this traditional instructor-led one-week course was developed to be used for nonresident training at duty stations.

AN/WSC-3 CBT Course. The CBT course, developed by Analysis & Technology, Inc., presents a structured multimedia tutorial to the student on a laptop computer. Extensive graphics were used to present the WSC-3 UHF transceiver and its internal components. Active participation by the student was required, to setup and operate a computer-simulated WSC-3 UHF transceiver, locate and remove its components, connect external test equipment (also simulated by the laptop), run tests, and answer test questions periodically. Along with the guidance provided by the tutorial, the student participated in a series of troubleshooting problems, that increased in difficulty as the student progressed through the course. The CBT course also had some humor built-in, as a grizzled old ET Chief who appeared on the display screen from time-to-time to provide timely hints and encouragement. Each student was expected to spend between six and fourteen hours with the CBT program, with an additional two hours of hands-on training to complete the WSC-3 course.

Experiment. The training effectiveness evaluation experiment compared three training strategies, using three groups of students from units around the country:

- **Nonresident CBT group (NC)** - The CBT version of the AN/WSC-3 course was individually conducted by 17 students, at 13 different USCG duty stations. The course was shipped to each student's duty station, prepackaged in a laptop computer. Following completion of the CBT material, each student received 2-hours of familiarization training with the actual transceiver hardware, to facilitate transition from the CBT media to the actual equipment.
- **Resident Instructor-led group (RI)** - The traditional one-week instructor-led AN/WSC-3 course was considered effective; it was the yardstick with which the CBT course was compared (i.e., primary control group). Thirteen students from multiple USCG units received this course, at one of the three times it was offered during the data collection period. The course was conducted in a classroom/lab environment.
- **Resident CBT group (RC)** - The CBT version of the AN/WSC-3 course was individually conducted by 16 students from multiple USCG units, at a USCG training center. The RC students received the same CBT course as NC students, but in the school environment. These RC students comprised a second control group.

The training and testing activities spanned a 7-month period. The NC students received the CBT course at their respective duty stations, after which they received the familiarization training and testing at a USCG training center. The RI students received the one-week course at the USCG training center, after which they received the same testing. The RC students received individualized CBT training, but in groups of 5 or 6 students at the USCG training center, where they also received the familiarization training and testing.

Evaluation of nonresident CBT effectiveness was based on comparing the performance of the NC students with that of the RI students. The training effectiveness measures were: 1) Pre- and post-training knowledge tests (multiple choice); 2) Hands-on test performance during troubleshooting of actual malfunctioning AN/WSC-3 UHF transceivers; and 3) Students' reactions given in a post-training questionnaire (These are reported together with the Implementation Analysis findings). Training time was also measured.

Equivalent versions of an electronics knowledge test were developed for the pretest and posttest. Each version addressed general electronics questions, and questions requiring detailed knowledge of the AN/WSC-3. Students received the pretest at their respective training sites. All students received the posttest and questionnaire at the USCG training center, where they also received the hands-on testing, after completing their training.

The hands-on test was developed to assess post-training proficiency in performing troubleshooting and corrective maintenance on transceivers in a lab at the USCG training center. Each student had to individually diagnose and repair five malfunctioning transceivers, in a near-work-like environment, similar to that of a duty station. Their performances were measured by experienced instructor-evaluators, using a highly-structured evaluation process developed for this experiment.

The procedures imposed on the groups during the training periods were limited to logistical constraints (e.g., scheduling NC students to report in groups for testing), and tasks to assure the CBT course was performed in an appropriate environment at the duty stations, without additional assistance.

Student Hands-On Test Performance

Student hands-on performance in solving the five malfunctioning WSC-3 problems was considered the single most important measure relating to the effectiveness of the training at duty stations. It replicated, to a degree, the types of problems and working environment ETs would encounter in the field. Two evaluators independently assessed each student's performance during each of the troubleshooting problems. The evaluation process for each problem required each evaluator to score multiple items under six dimensions (these corresponded to typical troubleshooting processes): symptoms, sectionalization, localization, isolation, corrective action, and overall performance (documentation and safety). The weighted scores from the evaluators were combined to yield a score for each problem, with the average score across problems providing the overall student score.

The mean hands-on performance achieved by students in each group was (see Figure 1):

NC: 91.81

RI: 87.87
RC: 92.00

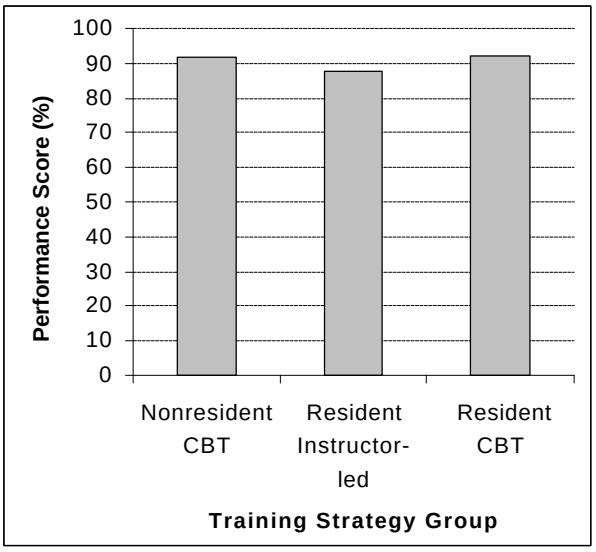

Figure 1. Hands-on test performance.

The RC group achieved the highest score, but only by a very small margin above the NC group (i.e., much less than 1%). And, the difference between these two CBT groups and the RI group was also small (i.e., about 4%). Furthermore, each group achieved the highest mean score on at least one of the five problems. A statistically significant effect was found for the training strategy variable, with the RC group performing significantly higher than the RI group. However, no significant differences were found between the NC and RC groups, nor between the NC and RI groups. Although this variable was statistically significant, these results suggest that little meaningful difference exists between the training strategies. That is, for practical purposes, the three training strategies were approximately equivalent in achieving AN/WSC-3 qualified ETs.

The RI group had the fastest average problem solving time, although no statistically significant differences were found between the groups.

Student Knowledge Test Performance

Student Entry Characteristics. The two versions of the knowledge test were constructed to be difficult, so as to allow discrimination between groups, and before-after training performance (i.e., measurement of training gain). The students, as expected, scored low on the pretest (average of 38%). Their performance on the AN/WSC-3 part of the test was about half that of the general part. These entry characteristics showed good potential for training gain.

Training Gain. Student performance on the posttest showed a substantial overall training gain, from 38% on the pretest to 61% on the posttest (see Figure 2). The training gain was found to be significant for each of the groups. The significant training gain, however, was limited to the AN/WSC-3 part of the test for all groups. The general part did not have a significant training gain for any group; this was expected, since the training focused on the AN/WSC-3. These findings demonstrated that each of the training strategies were effective in improving student knowledge about AN/WSC-3 maintenance.

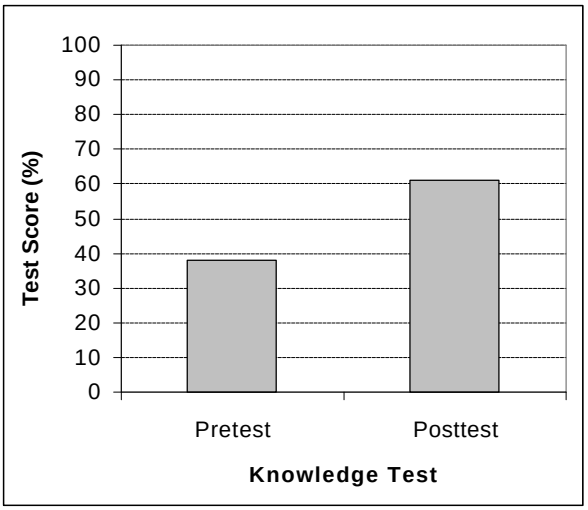

Figure 2. Knowledge test performance.

Posttest Performance. Student performance on the Posttest, similar to that of the hands-on test, showed only small differences between groups (see Figure 3):

NC: 60.44
RI: 64.00
RC: 57.57

This time, however, the RI group scored highest, with the NC group in the middle, and the RC group achieving the lowest mean Posttest score. This pattern was the same for the general and the AN/WSC-3 parts of the Posttest. The statistical analyses did not find significant differences between the groups, on either part of the posttest.

The Posttest results demonstrate findings similar to those of the hands-on problems. The CBT course was found to be equivalent to the resident instructor-led course. Of greater importance, the CBT course conducted in the nonresident duty station environment was found to be equivalent to both the resident instructor-led course and the CBT course conducted in the training center environment.

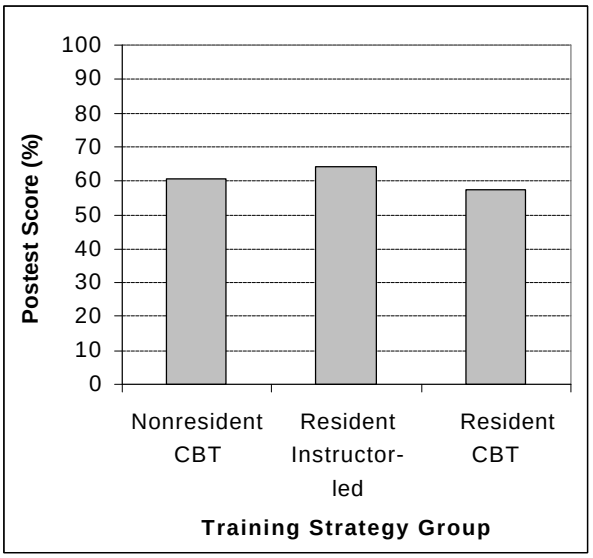

Figure 3. Mean posttest scores

Training Time

The training times differed greatly between the groups (see Figure 4), with the following mean times achieved:

NC:	12.93	hours
RI:	37.50	hours
RC:	7.82	hours

These times include the 2-hour familiarization session for the NC and RC groups. The training time of the RI group was the standard one-week course length, reduced to account for graduation, and other activities. It should be noted that the NC group training time includes one student who took over 35 hours to complete the course (i.e., as automatically recorded by the computer); no other NC student required above 20 hours.

These findings show an obvious and substantial training time advantage for the CBT courses, in comparison with the resident instructor-led course. They also show an advantage for the resident CBT course over the nonresident CBT course. This advantage is attributed to the school environment, which was likely to have been more conducive to training than those of the duty station environments during the study.

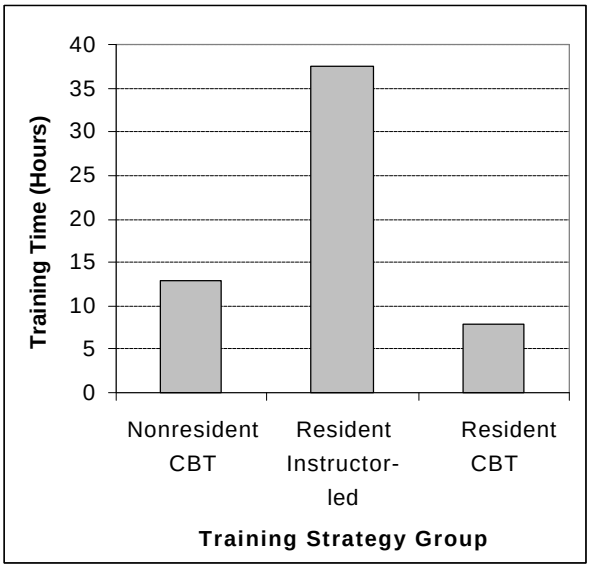

Figure 4. Mean training time.

Training Effectiveness Summary

The two sets of student performance data, hands-on troubleshooting problems and knowledge test, have found approximately equivalent student achievement by each of the three training strategies. These collective findings demonstrate that a USCG nonresident CBT maintenance course taught at duty stations can be equal in effectiveness to a resident instructor-led course taught at a training center. Furthermore, a substantial training time advantage can occur for CBT courses. These findings have important implications for the future direction of the USCG's training system, pointing to greatly expanded options for achieving cost-effective training delivery.

IMPLEMENTATION ISSUES

Interviews were conducted with the staffs of 7 of the USCG duty stations that had students trained as part of the NC group. The purpose was to identify issues and potential problems associated with the implementation of nonresident training, and suggestions for their amelioration.

The student questionnaires, filled-out by all students after completion of their training,

provided information similar to that of the interviews. The major findings of the NC group questionnaires and duty station interviews are presented together.

Potential Benefits of Nonresident CBT

The great majority of commanders, students and other staff providing information to the study supported the implementation of CBT at duty stations, in lieu of traditional resident instructor-led courses. They believe that nonresident training can succeed in the USCG, and will be a major benefit to duty stations. This support does not mean that all courses should be shifted to a nonresident CBT basis, but rather those that can be effectively conducted at duty stations should be transferred to that strategy.

The major benefits cited in favor of nonresident training were:

- **Increased flexibility for the USCG unit -** to perform its mission; and to meet its operations, training, and personnel needs. This would result from improved flexibility in scheduling training and operations; improved ability to achieve needed staff training; and greater staff availability at the unit to meet operations needs. Unit disruptions and staffing problems often associated with personnel away for training, may be substantially reduced when the training is local. Increased training efficiency is also expected, resulting in greater staff availability.
- **Facilitate the unit's general training requirements -** for new crewmembers, which are often considerable. A CBT capability at duty stations would enable these training requirements to be met with reduced staff participation, and may be more efficient.
- **Assist minimally-crewed cutters -** student separation time during training would be reduced; and, overall training time may also be reduced. Nonresident CBT was suggested as providing a partial solution to problems associated with minimally-crewed cutters.
- **Facilitate the pipeline training process -** by reducing the burden placed on a student's current unit, while undergoing pipeline training for the next duty station. The increased student availability and potential for reduced training time were cited as reasons.
- **Assist with unit emergencies -** Locally trained crewmembers would be available to assist during an emergency.
- **Training process enhancements -** including training efficiency (e.g., reduced training time), improved effectiveness associated with graphics media, self-paced training advantages, flexibility to return to previously covered material, greater consistency across multiple offerings of the course, and use of the training materials for refresher training at a later date.
- **Individual student benefits -** including reduction in family separation time, learning at the student's duty station, reduction in travel-related hassles, and less training time.

Several persons reported that their initial thoughts about the nonresident CBT course were negative, but changed after observing or using the course.

Obstacles to Effective Nonresident CBT

Although largely in favor of nonresident CBT, most persons cautioned that major obstacles must be overcome to achieve an environment at duty stations that is conducive to training. For example, all of the NC group students judged their training as effective, and most judged its quality as satisfactory, although several disagreed. The student responses suggest that at least several NC group students experienced training environment difficulties during their participation. Major potential threats to implementation of effective nonresident CBT, along with suggestions for their amelioration, were identified as (many relate to the above-cited benefits):

- **Unit flexibility -** The training process and procedures must provide the unit with flexibility to schedule and conduct training in accordance with the unit's particular situation (e.g., mission and operations constraints). A strong training management organizational structure at the duty station, and at other levels in the Coast Guard, was identified as necessary to enable unit flexibility. A key aspect cited was permitting each duty station reasonable authority to determine the training needs of their staff, and the training schedule.
- **Training time and scheduling -** Sufficient time should be provided daily, during normal work hours, for the conduct of training. Training should be scheduled like any other work task. Most training should not be

expected to take place during the student's personal time.

- **Student interruptions -** Interruptions must not be allowed while students are actively engaged in training during scheduled times, except for real emergencies. This was cited by many NC group students as a problem during their AN/WSC-3 CBT course.
- **Training environment -** The area and room in which a student is training must have an environment conducive to learning, such as minimizing distractions, noise, heat and vibrations.
- **Hands-on training** - Hands-on training may be a necessary component of many courses amenable to a nonresident training delivery strategy. Effective approaches must be developed to achieve this additional component; several are addressed in the project's report (Hammell, et al, 1998).
- **Student help -** Sources of technical assistance must be available to students, when needed. An assistance hotline (e.g., internet or telephone) was one approach considered viable to satisfy this need. Each duty station will require a facilitator to manage training and assist students with general training issues.
- **Student certification** - Valid approaches to student certification, after course completion, must be developed as part of the duty station training process. Several are addressed in the project's report (Hammell, et al, 1998).
- **Student motivation -** Motivation to train at their duty station was considered a major concern (e.g., some students would prefer the break from daily routine work that the resident schools provide). Student motivational incentives, such as time off, were suggested to address student motivation issues.
- **Training quality assurance -** Nonresident CBT will require a greater degree of quality assurance than resident instructor-led training, due to several reasons, such as the much wider dispersion of training responsibility. Quality assurance should include quality control of the on-going training process, in a manner that is not intrusive to duty stations; and, proactive evaluation of the training media and materials, to insure that they remain current in meeting the workforce's changing training needs.

Most students and staff interviewed stated that the identified implementation problems, although potentially serious threats to effective training at duty stations, can be dealt with by proper development, organization and management. The report cites many additional issues (Hammell, et al, 1998).

Conversions of courses from resident to nonresident CBT would likely include 1) complete course conversions; 2) partial course conversions, in which a resident course would be shortened, and preceded or followed by a nonresident CBT part; and 3) re-structuring of multiple resident courses into a new mix of resident and nonresident CBT courses.

COST COMPARISON

Methodology

The cost comparison analysis used the cost data associated with the experimental AN/WSC-3 course to develop cost values for the nonresident CBT version delivered to students at their duty stations. For the resident, instructor-led side of the cost comparison analysis, costs related to the operation of the instructor-led version of the AN/WSC-3 course were used. A list of the cost factors considered for both sides of the analysis are presented in Table 1. Investment costs are non-recurring costs associated with the creation of a course (e.g., Instructional Systems Development process), and preparations for its implementation. Operations and Maintenance (O&M) costs are recurring costs, which are incurred on a yearly basis. Per Student costs are recurring costs that are associated with student participation in a training activity.

The analysis was performed with a cost model developed using spreadsheet software. Model development occurred through an iterative process, in parallel with data collection and analysis. Developing the model in this manner allowed the analysts to:

- Gain a better understanding of the cost issues facing the USCG training community;
- Have various people, both inside and outside the USCG (e.g., U.S. Naval Air Warfare Center, FBI National Security Training), perform reviews of the model during its development;
- Use the model as a tool for communication of ideas between the

analysts, and potential information sources (e.g., USCG training centers).

The model applies the Capital Expenditure Analysis methodology (Gray and Ricketts, 1982), which is an accepted and widely used procedure. It provides information that a decision-maker would use to determine whether or not to make an investment. For this cost comparison analysis, the investment decision was between staying with an existing instructor-led resident course (ILRES), or developing and implementing an equivalent, nonresident CBT version of that course (NRCBT). The analysis concentrated on Pay-back Period (break-even point in years), Total Savings over the life-span of a given course, and Net Present Value (NPV) of Total Savings.

Table 1. Cost Factors Considered in Cost Comparison Analysis

COST CATEGORY	NONRESIDENT CBT COURSE	INSTRUCTOR-LED RESIDENT COURSE
Investment	CBT Design & Development USCG Subject Matter Expert Support Equipment for Course Distribution	Classroom & Lab Space Classroom & Lab Equipment
Operations & Maintenance	Distribution Center Operations & Personnel Student Support (e.g., Help Desk) Courseware Maintenance	Training Center Operations & Personnel
Per Student	Student Time Duty Station Facilitator Time Shipping Of Course Material Student Materials	Student Time Student Transportation Per Diem Student Materials

Two scenarios were considered for the cost comparison. Scenario One was based on the replacement of a single existing ILRES course with an equivalent, NRCBT version of the same course. This kind of replacement would have little impact on a training center's operation and personnel budget requirements. Elimination of resident costs (cost avoidance), as a result of replacing the ILRES course would be limited to Per Student Costs (i.e., Student time, student materials, student transportation, and per diem).

Scenario Two was based on the replacement of a "meaningful" number of existing ILRES courses with NRCBT versions of those courses. This allows re-organization of the USCG training structure to save approximately the proportion of training center costs shared by each course conversion. As a result, all costs associated with operating and staffing a training center were considered.

An Annual Student Throughput Rate of 72 students and a Course Life-span of 7 years was used in the cost model runs for both scenarios. These were considered as reasonably conservative values. Costs associated with course revisions over the life of a course are accounted for through inclusion of a Courseware Maintenance cost factor.

Cost Analysis Results

The results the analysis are presented in Table 2. They show that Pay-back Period, Total Savings, and NPV of Total Savings support investment in the NRCBT version of the course for both scenarios. However, the Scenario Two situation results in much greater projected savings, as Pay-back Period is decreased by 65 percent, Total Savings is 8 times as great as that calculated for Scenario One, and NPV of Total Savings is greatly increased over that of Scenario One.

Table 2. Results of Cost Comparison for the Two Scenarios

Scenario	Pay-Back Period (Years)	Total Savings Over 7 Years	NPV of Total Savings (5.8 %)
One	5.31	$ 85K	$ 4K
Two	1.85	$ 742K	$ 544K

A sensitivity analysis revealed that the savings are very sensitive to changes in Annual Student Throughput Rates for both scenarios. If the Annual Student Throughput Rate drops below 60 students in Scenario One, a loss would occur when considering a 7-year Course Life-span. Although Total Savings for Scenario Two was sensitive to changes in the Annual Student Throughput Rate, at no point did Total Savings result in a loss. However, as would be expected with any scenario considered, if Course Life-span were to fall below the Pay-back Period, a loss would result for Scenario Two.

The increased savings and shorter Pay-back Period realized from nonresident CBT, in comparison to the costs of operating and staffing a training center, provides the decision maker with a margin-for-error and a source of funds for reinvestment to infrastructure. A margin-for-error is important to the decision maker as any decision regarding investment is based on estimations of future events and costs. An appropriate infrastructure will need to be developed and deployed by the USCG, to support the successful implementation of nonresident training delivered at the duty station via a media mix. The increased savings potential associated with nonresident CBT provides a source of funds which could be reinvested into development and implementation of the required infrastructure, and still have funds remaining which could be used by the USCG to meet other mission needs as well.

CONCLUSIONS AND RECOMMENDATIONS

Nonresident CBT maintenance courses conducted at USCG duty stations can be as effective as courses conducted at shoreside training centers. The USCG should proceed with the implementation of nonresident training at duty stations.

The equivalent effectiveness of nonresident training and resident training refers to a potential of equality, rather than a certainty of equality. The actual long-term effectiveness of nonresident training will depend heavily on the manner in which the training is conducted.

Care must be exercised in selecting courses that will be conducted at duty stations, since it is unlikely that all courses will be fully amenable to a nonresident CBT training strategy.

Reduced training time is a potentially major benefit of nonresident CBT, in comparison with resident instructor-led training.

Student motivation is a particularly important factor affecting the success of nonresident CBT. It must be effectively addressed.

The staff at USCG duty stations largely support nonresident CBT, although they are concerned about how it will be implemented. Changes within the USCG are necessary to effectively shift a substantial portion of training to duty stations, such as the establishment of an effective duty station training quality assurance program.

A centralized quality assurance process should be developed as a check-and-balance, to assure that an adequate level of training effectiveness is developed and maintained at all duty stations.

The cost comparison analysis showed that nonresident CBT provided to students at duty stations can save training dollars. However, it is important to note that other nonresident media options are available which may be cheaper to implement, such as interactive video-teleconferencing. Actual savings realized by the USCG from nonresident CBT will be dependent on the cost factors which are affected by the conversion of instructor-led resident courses, and the cost of the infrastructure required to support nonresident training at duty stations.

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