NPS-LM-14-178

ACQUISITION RESEARCH PROGRAM
SPONSORED REPORT SERIES

Implications of Using Computer-Based Training on System Readiness and Operating & Support Costs

18 July 2014

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Prepared for the Naval Postgraduate School, Monterey, CA 93943.

Report Documentation Page

Form Approved
OMB No. 0704-0188

1. REPORT DATE	2. REPORT TYPE	3. DATES COVERED
18 JUL 2014		**00-00-2014 to 00-00-2014**

4. TITLE AND SUBTITLE
Implications of Using Computer-Based Training on System Readiness and Operating & Support Costs

5a. CONTRACT NUMBER
5b. GRANT NUMBER
5c. PROGRAM ELEMENT NUMBER

6. AUTHOR(S)

5d. PROJECT NUMBER
5e. TASK NUMBER
5f. WORK UNIT NUMBER

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
Naval Postgraduate School,Defense Resources Management Institute,Monterey,CA,93943

8. PERFORMING ORGANIZATION REPORT NUMBER

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)

10. SPONSOR/MONITOR'S ACRONYM(S)

11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release; distribution unlimited

13. SUPPLEMENTARY NOTES

14. ABSTRACT
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15. SUBJECT TERMS

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT **unclassified**	b. ABSTRACT **unclassified**	c. THIS PAGE **unclassified**	**Same as Report (SAR)**	**33**	

Standard Form 298 (Rev. 8-98)
Prescribed by ANSI Std Z39-18

The research presented in this report was supported by the Acquisition Research Program of the Graduate School of Business & Public Policy at the Naval Postgraduate School.

Abstract

In the early 2000s the U.S. Navy decided to replace traditional, instructor led schoolhouse training with Computer Based Training (CBT). The move was expected to reduce training cost and time without negatively affecting the quality of sailors arriving to the Fleet. If the conversion to CBT were to have an effect anywhere in the Navy maintenance system, it should be seen in maintenance activities where sailors were performing maintenance on ships. Anecdotal evidence suggests that CBT failed to sufficiently prepare new sailors for on board maintenance and operations.

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Keywords: system readiness, operations, costs, computer based training (CBT), maintenance

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Implications of Using Computer-Based Training on System Readiness and Operating & Support Costs

Introduction

The majority of specialized skills training (known as class 'A' and 'C' schools) in the United States Navy has traditionally taken place in a classroom setting with live instruction. At the turn of the century Navy leadership became concerned that current training programs would not adequately meet future demands. As a result, the Chief of Naval Operations (CNO) chartered an Executive Review of Navy Training (ERNT) to review the Navy training system and recommend solutions to improve training effectiveness and meet future training demands.

The ERNT group noted that formal schoolhouse training requires a large investment in facilities, instructors, and laboratories and that future training demand would exceed capacity. The ERNT group recommended using new training technologies to meet future demands while reducing training costs and time (Executive Review of Navy Training (ERNT), 2001). Motivated by these findings, the Navy established Task Force EXCEL (Excellence through Commitment to Education and Learning) to develop a continuum of lifelong learning, use a streamlined funding process and a single training authority, create a Human Performance Systems Model (HPSM), and to link training and acquisition (Naval Personnel Development Command, 2002).

Part of the Navy's new strategy included the use of new training technologies such as distributed learning, computer based training (CBT), collaborative learning, and computer-mediated learning. The Navy claimed that the introduction of CBT would reduce both training time and training costs without reducing the quality of training received (ERNT, 2001). Accordingly, CBT was introduced full-time into the training pipeline in FY2003.

A 2009 Naval Inspector General (IG) Report, *Computer Based Training*, found that while the introduction of CBT did reduce training time relative to the A and C schools, it may not have adequately prepared sailors for their initial duty assignments. Anecdotal evidence suggested that sailors trained with CBT did not usually meet the required Knowledge, Skills, Abilities, and Tools (KSATs) to perform their duties effectively upon reporting on board. Because of this, ships had to take the time to train sailors up to acceptable standards. Initial evidence also suggests that the use of CBT may have transferred these costs to the operational fleet (Naval Inspector General, 2009).

To understand the operational cost impact of CBT we need to know whether CBT reduced the overall cost of operations and maintenance, including on-the-job training, unscheduled maintenance actions, and the length of repairs for systems requiring intensive education and training.

In this study we examine the impact of CBT on a single system, the AN/SQQ-89(v) sonar[1], to determine whether CBT significantly altered fleet maintenance costs, actions, and training requirements for this system. If CBT has effectively trained personnel, then costs, labor hours, and corrective maintenance actions should either remain constant or decline. On the other hand, if CBT is an ineffective replacement for traditional 'hands-on' training, then, after controlling for other factors, costs, labor hours, and corrective maintenance actions should increase. We recognize that focusing on one system will limit the inferences about CBT's effect, however, we maintain that these inferences will still of be interest to practitioners and policymakers alike.

The next section discusses the Navy's traditional and computer based training. The third section briefly describes Navy maintenance and the fourth section describes the AN/SQQ-89(v) sonar system and the data used in this study. The fifth section analyzes whether CBT has affected maintenance costs, actions, or time. The last section concludes and offers directions for future research.

Training

Navy sailors receive training throughout their careers. Once a recruit has completed basic training, he or she will attend specialized skill training in their designated job specialty or "rating." In-rate training begins in a class "A" school,[2] where sailors learn the particular skills specific to their job. From there, a sailor may also attend additional in-rate training in a "C" school.[3] After completing school training, the sailor is assigned to an initial duty station, where training will continue "on-the-job" as he or she gains real world experience in their specialized skill.

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[1] The AN/SQQ-89(v) surface ship Anti-Submarine (ASW) Warfare combat system is an integrated network of sonar systems designed to search, detect, classify, and engage ASW threats (Lockheed Martin, 2009)

[2] For further information on qualifications for and assignments to class "A" schools, see MILPERSMAN 1306-618, 'Class "A" School and Rating Entry Requirements.' Available at: http://www.public.navy.mil/bupers-npc/reference/milpersman/1000/1300Assignment/Documents/1306-618.pdf

[3] A submarine Fire Control Technician, for example, attends a 27 to 33 week A school course on basic skills, followed potentially by a C school course on advanced maintenance topics, including computer language skills and maintenance of specific weaponry.

Additionally, sailors can expect to receive general military training in topics ranging from electrical safety to suicide prevention.

Traditional Schoolhouse Training

Until the early 2000s, the Navy conducted in -rate training in a formal schoolhouse setting using subject matter experts (SMEs) to instruct new sailors. These instructors typically came from the Fleet and had practical experience with the work and responsibilities of newly rated sailors. In addition, they were able to supplement the lecture material with tips and anecdotes from their own career experiences (Naval Inspector General, 2009).

In the traditional schoolhouse environment sailors could reinforce their understanding of the lecture material through hands-on practice in a laboratory setting, working on the same equipment they would use and maintain in the Fleet. In the laboratory, instructors were able to simulate equipment failures for technicians to troubleshoot and students were able to ask questions as they learned. Because the instructors were observing and interacting with the students in person, the delivery of material (lecture or practical application) could be tailored to improve the students' level of comprehension. For example, if a class had difficulty understanding a particular concept, the instructor could choose to spend more time in the lab to reinforce what is learned during the classroom portion.

There are several benefits to Instructor Led Training (ILT). Since a single instructor teaches a large group of students, group learning techniques can be employed that would otherwise be unavailable in one-on-one or CBT instruction. The formation of small groups within a class fosters team-building and allows students to help and teach each other. Compared to the costs of software development, testing, and hardware purchase, ILT is in some ways more cost-effective, depending on class size and length of use. Additionally, the controlled classroom environment offers fewer distractions than CBT or distance learning. Finally, ILT doesn't take as long to develop as CBT. It takes approximately 34 hours to develop one hour of ILT (Chapman, 2007), while it takes approximately 220 hours to develop a standard e-learning course (Chapman, 2006).

ILT also has its disadvantages. Since everyone has different learning capabilities, some students may be more advanced and become bored while waiting for slower learners to catch up. Conversely, slow learners may have difficulty keeping up. Depending on the size and duration of the course, ILT may be more expensive than CBT.

Revolution in Training

In October 2000, the Executive Review of Navy Training (ERNT) group was charged with providing insights on how to improve and align training organizations, leverage civilian training practices, and use new technologies to provide a continuum of training for sailors. The 24-member group was comprised of military and civilian personnel, members of academia, research institutions, and industry. In 2001, ERNT released their report, *Revolution in Training: Executive Review of Navy Training Final Report*.

During their review, the ERNT group noted that the demands for training had increased. The ERNT group noted that the finite number of seats available in the Navy schoolhouses would not be able to support the increased training demands. Because of this, there were gaps in the types of training that current and/or potential sailors needed and what could be delivered. In many cases, this resulted in billets which could not be filled because there were no sailors with the required training to fill them.

During the 1990s several other items contributed to the lack of trained sailors. First, the pool of experienced sailors had decreased due to drawdowns and retirements. Second, it was difficult to compete for trained personnel in a healthy U.S. economy and many trained sailors were leaving for jobs in the civilian sector.

The ERNT group suggested that technology and the science of learning offered several opportunities to improve the Navy training system by reducing training time through CBT and offering distributed learning opportunities that could be executed at the workplace.

Computer-Based Training

Computer-based training or CBT is defined as “individual or group self-paced instruction using a computer as the primary training medium, to include web-delivered Navy E-Learning (NEL)” (Naval Inspector General, 2009, p. ii). In Navy A schools, students go through learning modules on a personal computer at their own pace. When a student is done processing the information presented on the screen, they click “next” to proceed to the next piece of information. There are usually small knowledge assessments throughout the module, followed by a comprehensive evaluation at the end of the module (Naval Inspector General, 2009, p. 7).

Because the learning is self-paced, instructors were replaced with “facilitators” who are primarily concerned with maintaining order in the classroom, monitoring student progress, and providing technology assistance. Facilitators are not necessarily SMEs in the subject matter being delivered in the CBT modules. They do not provide instruction or answer questions related to the course content.

The removal of instructors from the classroom may have a detrimental effect on learning for those students who cannot grasp the material on their own.

The introduction of CBT in the class A schools has considerably altered the nature of instruction. Using a personal computer, sailors can progress through learning modules at their own pace or work together in groups to complete the course material (Barker, 2010). In 2010 the GAO noted that the fleet had concerns over the level of knowledge that sailors reporting to ships from A schools using CBT demonstrated. The Navy IG noted that sailors arriving to the fleet under CBT did not usually meet the required Knowledge, Skills, Abilities, and Tools standards (KSATs) and were unfamiliar with the equipment they would be working on and the tools they would need to use. Because of this, ships had to take the time to train sailors up to acceptable standards. In Fleet interviews, some commands reported that specialty qualification time was nearly double what it had been before the introduction of CBT (Naval Inspector General, 2009). GAO reports in 2010 and 2011 made similar observations and concluded that the change to CBT had a negative impact on readiness.

The Navy IG and GAO reports found that while the Navy's use of CBT resulted in cost and training time savings, sailors reporting to the Fleet were not as well prepared as ILT-trained sailors of the past. The result is that poorly-trained sailors may have contributed to declining material readiness in the Fleet. The next section of this study reviews Navy maintenance practices.

Maintenance

Navy maintenance occurs on three levels: organizational level (O-level), intermediate maintenance (IM) activities, and depot level. This section of the study will discuss all three maintenance levels.

Shipboard maintenance begins with the Planned Maintenance System (PMS). PMS is governed by Naval Sea Systems Command (NAVSEA) Instruction 4790.8B, *Ship's Maintenance and Material Management (3-M) Manual*. The instruction outlines the requirements for PMS on shipboard systems and equipment (Naval Sea Systems Command, 2003). The purpose of PMS is to provide ships with the means to plan, schedule, and perform preventive maintenance onboard and to identify potential equipment problems before the equipment fails.

If corrective maintenance is required, the maintenance is reported, scheduled, and performed through organizational level (O-level) shipboard maintenance. Ship maintenance actions are reported in Navy Visibility and Management of Operating and Support Costs (VAMOSC), under Unit Level Consumption and Manhours—Organizational Corrective Maintenance.

Intermediate maintenance (IM) is "normally performed by Navy personnel onboard tenders, repair ships, Shore Intermediate Maintenance Activities (SIMAs), aircraft carriers, and fleet support bases." (Naval Sea Systems Command, 2003, pp. I-5) IM jobs are deferred corrective maintenance jobs that are beyond the capability of ship's force and are sent off-ship for completion. IM is tracked in Navy VAMOSC under Maintenance – Intermediate.

Depot level maintenance "requires major overhaul or a complete rebuilding of parts, assemblies, subassemblies, and end items, including the manufacturing of parts, modifications, testing, and reclamation." (Naval Sea Systems Command, 2003, pp. I-5). Depot maintenance is reported in Navy VAMOSC under Maintenance and Modernization – Depot, Other Depot.

In 2009 VADM (Ret.) Phillip Balisle was directed to conduct a Fleet Review Panel (FRP) of surface force material readiness. The report noted that 4,052 billets were removed from Navy ships from 2001–2009. While billets were removed from ships, requirements such as maintenance, damage control watches, training, and in port duties were not reduced (Balisle, 2010). The shortcomings of CBT described in the previous section exacerbated the problems experienced with manning reductions since sailors were not arriving on board with the right KSATs. The result was undermanned ships with poorly trained sailors with not enough time or know-how to perform routine maintenance actions.

In addition to reduced fleet manning, shore facilities also received manning cuts. This means that maintenance that was intended for intermediate maintenance activities was pushed back to ship personnel, which were undermanned and poorly trained. In addition to the shrinking shore workforce, the amount of time the ships are available was shortened from 15 weeks to 9 weeks (Balisle, 2010). These actions resulted in equipment being out of commission for longer periods of time.

Finally, the 2010 Balisle report noted that changes in PMS were made because ships couldn't meet maintenance requirements due to reduced manning. Maintenance requirements were either eliminated or extended in periodicity. The intent was to shift maintenance requirements to shore facilities, but since manning was reduced ashore, many requirements went away completely. The elimination and extension of maintenance requirements can lead to more opportunities for equipment to become inoperable, resulting in degraded Fleet readiness (Balisle, 2010).

The Navy introduced several major changes to training, maintenance and manning policies during the early part of the 2000–2010 decade. The Balisle report found that training was a factor but certainly not the only factor that led to degraded Fleet readiness. Manning reductions would have led to cost savings in the military personnel budget, but the impact of the reductions may have resulted in maintenance cost increases in future budgets due to deferred maintenance actions, thus confounding the effect of CBT. Similarly, changes in maintenance policies may have impacted maintenance costs in future years.

At a macro level the impact of CBT is impossible to tease out (see Gibson, 2012, for an examination of Navy training, operations and maintenance budgets between 2000 and 2012). For this reason, this study examines one system in particular, the AN/SQQ-89(v) sonar system, collecting data at a level of detail that allows for the control of the various variables that might impact maintenance costs..

The AN/SQQ-89(V) Sonar System

To examine the effect of CBT on rising maintenance costs, this study will focus on the O&S costs of a single Navy system, the AN/SQQ-89(v) sonar system, and look at how the conversion to CBT affected maintenance costs in that system. We selected this system because it is fielded throughout the operational fleet before and after the implementation of CBT. Analysis by Gibson in 2012 revealed that technicians did not change significantly from FYs 2000–2010, effectively eliminating manning as a contributor for the AN/SQQ-89 O&S costs and focusing the study on training and maintenance.

The AN/SQQ-89(v) surface ship Anti-Submarine (ASW) Warfare combat system is an integrated network of sonar systems designed to search, detect, classify, and engage ASW threats. The system is currently installed on CG-47 class cruisers, DDG-51 class destroyers, and FFG-7 class frigates. The AN/SQQ-89(v) employs a variety of sensors that can transmit and receive acoustic data to detect and classify threats.(Jane's Information Group, 2010).

The AN/SQQ-89 system consists of 15 different variants. Variants differ based on the sensors chosen and the version of each sensor. In this report only variants 2, 3 4, 6, 7 and 9 were studied. These variants were chosen because they were on board ships prior to the introduction of CBT into the sonar training pipeline (2003) and remained on board after CBT was introduced. This allows for analysis of ship maintenance trends both prior to and after the introduction of CBT.

All sonar technicians-surface (STGs) attend STG A school. At A school they learn the basic principles of oceanography and sound. Following A school, STGs who are strictly operators report to a Sonar Operator course, while maintainers attend C school, where they learn the technical skills required to maintain the equipment present on their reporting ship (Navy Personnel Command, 2012). CBT was introduced full-time into the training pipeline in FY2003, after the recommendations of the ERNT report (Naval Inspector General, 2009). This study focuses on FYs 1999 through 2010 to capture data prior to and after the introduction of CBT.

Program Executive Office Integrated warfare System 5 (PEO IWS5) provided a list of ships equipped with the AN/SQQ-89(v) sonar system. The list included ship class, ship name, hull number, homeport, and 89 variant number. Only ships with AN/SQQ-89(v) variants on board both before and after implementation of CBT were considered. The initial list provided by PEO IWS5 included all ships of the CG-47, DD-963, DDG-51, and FFG-7 classes. To narrow the ship list to match the scope of our study, ships were removed from the data set if:

- The ship was decommissioned during the FY95-06 timeframe
- The ship received a variant upgrade
- The ship was commissioned FY2000 or later
- The ship was outfitted with a variant introduced after FY03

Using the above criteria, the ship list was reduced to 68 ships. A list of ships per variant is given in Table 1.

Table 1. List of Ships and AN/SQQ-89(v) System Variants used in this study

(V)2	SHIP	HOMEPORT
CG 55	LEYTE GULF	Norfolk, VA
FFG 8	MCINERNEY	Mayport, FL
FFG 28	BOONE	Mayport, FL
FFG 29	STEPHEN W GROVES	Mayport, FL
FFG 32	JOHN HALL	Mayport, FL
FFG 33	JARRET	San Diego, CA
FFG 36	UNDERWOOD	Mayport, FL
FFG 38	CURTS	San Diego, CA
FFG 39	DOYLE	Mayport, FL
FFG 40	HALYBURTON	Mayport, FL
FFG 41	MCCLUSKY	San Diego, CA
FFG 42	KLAKRING	Mayport, FL
FFG 43	THACH	San Diego, CA
FFG 45	DE WERT	Mayport, FL
FFG 46	RENTZ	San Diego, CA
FFG 47	NICHOLAS	Norfolk, VA
FFG 48	VANDEGRIFT	San Diego, CA
FFG 49	ROBERT G BRADLEY	Mayport, FL
FFG 53	HAWES	Norfolk, VA
FFG 55	ELROD	Norfolk, VA
FFG 56	SIMPSON	Mayport, FL
FFG 57	REUBEN JAMES	Pearl Harbor, HI
FFG 58	SAMUEL B ROBERTS	Mayport, FL
FFG 59	KAUFFMAN	Norfolk, VA
FFG 60	RODNEY M. DAVIS	Everett, WA
FFG 61	INGRAHAM	Everett, WA

(V)3	SHIP	HOMEPORT
CG 56	SAN JACINTO	Norfolk, VA
CG 57	LAKE CHAMPLAIN	San Diego, CA
CG 58	PHILIPPINE SEA	Mayport, FL

(V)4	SHIP	HOMEPORT
DDG 51	ARLEIGH BURKE	Norfolk, VA

(V)7	SHIP	HOMEPORT
CG 66	HUE CITY	Mayport, FL
CG 67	SHILOH	Yokosuka, Japan

(V)9	SHIP	HOMEPORT
FFG 37	CROMMELIN	Pearl Harbor, HI
FFG 50	TAYLOR	Mayport, FL
FFG 51	GARY	San Diego, CA
FFG 52	CARR	Norfolk, VA
FFG 54	FORD	Everett, WA

(V)6	SHIP	HOMEPORT
CG 68	ANZIO	Norfolk, VA
CG 69	VICKSBURG	Mayport, FL
CG 70	LAKE ERIE	Pearl Harbor, HI
CG 71	CAPE ST GEORGE	San Diego, CA
CG 72	VELLA GULF	Norfolk, VA
DDG 52	BARRY	Norfolk, VA
DDG 53	JOHN PAUL JONES	San Diego, CA
DDG 54	CURTIS WILBUR	Yokosuka, Japan
DDG 55	STOUT	Norfolk, VA
DDG 56	JOHN S. MCCAIN	Yokosuka, Japan
DDG 57	MITSCHER	Norfolk, VA
DDG 58	LABOON	Norfolk, VA
DDG 59	RUSSELL	Pearl Harbor, HI
DDG 60	PAUL HAMILTON	Pearl Harbor, HI
DDG 61	RAMAGE	Norfolk, VA
DDG 63	STETHEM	Yokosuka, Japan
DDG 64	CARNEY	Mayport, FL
DDG 65	BENFOLD	San Diego, CA
DDG 66	GONZALEZ	Norfolk, VA
DDG 67	COLE	Norfolk, VA
DDG 68	THE SULLIVANS	San Diego, CA
DDG 69	MILIUS	San Diego, CA
DDG 70	HOPPER	Pearl Harbor, HI
DDG 71	ROSS	Norfolk, VA
DDG 72	MAHAN	Norfolk, VA
DDG 73	DECATUR	San Diego, CA
DDG 74	MCFAUL	Norfolk, VA
DDG 75	DONALD COOK	Norfolk, VA
DDG 76	HIGGINS	San Diego, CA
DDG 77	O'KANE	Pearl Harbor, HI
DDG 78	PORTER	Norfolk, VA

Navy Visibility and Management of Operating and Support Costs (VAMOSC) provided O&S cost data, underway steaming days, and selected non-cost data for ships equipped with the AN/SQQ-89 sonar system covering FYs 1995 through 2010. Cost figures were given in then-year and constant FY2011 dollars.

In addition to the AN/SQQ-89 sonar system data, detailed ship data was available for the selected ships. Non-cost data included number of personnel trained, maintenance manhours, and number of maintenance actions. Table 2 shows the variables used in our analysis and table 3 shows the descriptive statistics for the data.

Table 2. Variables and data sources

Name	Definition	Units of Measurement	Source
Organizational Parts Costs	Cost of repair parts used by the ship's personnel in system maintenance and alterations	Constant FY 11 Dollars	Naval Visibility and Management of Operating and Support Costs (VAMOSC)
Corrective Maintenance Actions	Number of corrective maintenance actions performed onboard ship	Actions	VAMOSC
Organizational Labor Hours	Corrective maintenance hours performed onboard ship	Hours	VAMOSC
Authorized on Board, E1 through E6	Sailors authorized on a ship for a fiscal year	Individuals	Navy Personnel Command
Navy Manning Plan, E1 through E6	Sailors planned for a ship a fiscal year	Individuals	Navy Personnel Command
Currently on Board, E1 through E6	Sailors on board a ship at end of a fiscal year	Individuals	Navy Personnel Command
Days Underway	Days spent at sea	Days	VAMOSC

Table 3. Descriptive statistics

Series	N	Mean	Standard Deviation	Minimum	Maximum
Organizational Parts Costs	802	8439.80	9434.82	0	65839.71
Corrective Maintenance Actions	793	75.10	54.05	4	447
Organizational Labor Hours	801	1012.60	1029.57	7	12079
Authorized on Board, E1 through E6	808	12.66	3.66	6	18
Navy Manning Plan, E1 through E6	812	12.8	4.09	5	20
Currently on Board, E1 through E6	811	12.92	4.13	4	24
Days Underway	543	135.80	48.77	24	281

A graphical analysis by Gibson in 2012 indicated noticeable changes after the introduction of CBT. For example, Labor Ashore—Intermediate Maintenance Manhours showed significant change (see Figure 1). The figure shows number of manhours spent on IM for selected ships from FYs 1995 through 2010. Beginning in FY04, the IM manhours increased significantly for the selected DDG-51 and CG-47 class ships.

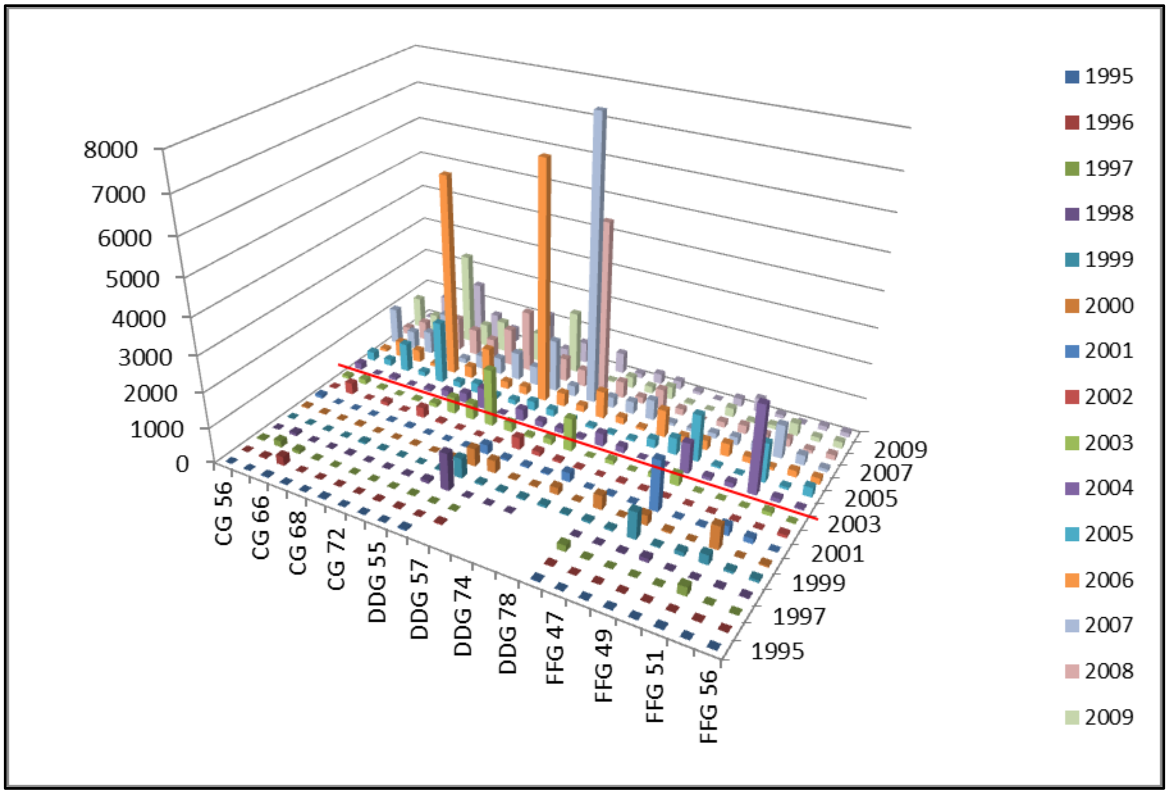

Figure 1. Labor Ashore - Intermediate Maintenance Manhours

Analysis & Results

To test the hypothesis of whether the introduction of CBT significantly influenced system maintenance and operation we define three dependent variables of interest: Organization Parts Costs (*OrgParts*), Corrective Organizational and Intermediate Maintenance Actions (*OrgActions*), and Organization Labor Man-Hours (*Orghours*). If CBT does not detract from sailor ability, then we expect CBT to have no (or negative) impact on the dependent variables. If CBT does not adequately prepare sailors for operating and maintaining these systems when compared to traditional training, then we expect an increase in parts costs, maintenance actions, and man-hours.

Computer Based Training (CBT) is a dummy variable that is 0 before 2004 and 1 afterwards. Billets authorized for enlisted grades E-1 to E-6 (*BAE)*, the Navy Manning Plan for enlisted personnel in grades E-1 to E-6 (*NMPE*), number of enlisted in grades E-1 to E-6 currently on board (*COBE*), and the number of days underway in a given fiscal year (*UW*) are used as control variables. A matrix **Z** includes the radar variant, radar's installation year, type of ship, and homeport location. The data collected can be characterized as panel data and the following general estimation form is used:

$$y_{it} = \alpha + \beta_1 CBT_{it} + \beta_2 BAE_{it} + \beta_3 NMPE_{it} + \beta_4 COBE_{it} + \beta_5 UW_{it} + \varphi Z_{it} + \mu_i + \lambda_t + u_{it} \qquad (1)$$

where μ_i and λ_t denote the unobservable individual ship and time effects, respectively. The term u_{it} is a random walk. The subscripts i and t denote ship and time period, respectively.

To examine the hypothesized influence of CBT on AN/SQQ-89(v) parts costs, maintenance man hours, and maintenance actions, only those variants on board prior to and following CBT's introduction into the A and C schools are used. Of the fifteen possible variants, data on five variants are used for the empirical analysis from FY 1999 through FY 2010. The final data set contains 526 observations on 68 ships from FY 1999 to FY 2010.

Results from pooled Ordinary Least Squares (OLS) estimators are presented in Table 4. The analysis explicitly assumes that CBT is exogenous to the dependent variables since CBT is a policy decision. The results indicate that the use of CBT has *adversely* influenced parts costs, actions, and labor hours associated with operating and maintaining the AN/SQQ-89(v). This result is consistent when we control for the type of ship, radar variant, homeport, and unobservable ship and time characteristics. These results suggest that the navy has traded an explicit training cost for an obscured cost in terms of parts, maintenance actions, labor hours, and readiness.

Table 4. Estimates for the impact of CBT (constant FY11 dollars)

Pooled OLS	Organizational Parts Costs	Corrective Maint Actions	Organizational Maint Hours
$Parts_{t-1}$	---	---	---
Computer Based Training	4971.45** (1894.62)	32.86** (11.51)	730.21** (170.17)
Billets Authorized	581.46 (373.73)	5.18* (2.53)	-33.35 (45.09)
Navy Manning Plan	-226.72 (338.25)	-3.53 (2.22)	4.85 (39.24)
Currently On Board	-332.35+ (188.27)	-0.12 (0.85)	17.34 (19.12)
Constant	8159.01** (2789.05)	57.75** (19.80)	954.13 (384.28)
F	7.58**	16.11**	9.55**
R^2	0.20	0.27	0.22
Observations	790	779	787
M1	3.24**	4.37**	3.72**
M2	1.95*	2.26*	1.73+

Notes: **,*,+ denote significance at the 1%,5%, and 10% level respectively.

Our analysis suggests that using CBT increases Organizational Parts Costs by approximately $4,971 per year at the 1% level of significance. For a given system on a ship, this suggests a 20 to 50% increase in maintenance costs over time. We also find that CBT increases Corrective Maintenance Actions by approximately 32 per year at the 1% level of significance. For a given system on a ship, this suggests a significant percentage increase in maintenance actions. Finally, we estimate that introducing CBT inflates the number of Organization Labor Hours by 730 hours at the 1% level of significance.

Our results support the anecdotal arguments that CBT negatively impacts sailor performance on ships, affecting parts costs, maintenance actions, and maintenance labor hours. While limited to one system, this result suggests that the navy has reduced the cost of labor and equipment in schoolhouses at the expense of operational cost and effectiveness (parts, maintenance, and labor hours) on board ships.

Conclusion

In 2001, ERNT released its report, *Revolution in Training: Executive Review of Navy Training Final Report*, which led to a major overhaul in the US Navy's training practices, including the use of CBT in A and C schools. Anecdotal evidence from the Fleet suggested that the quality of training received by sailors through CBT was not as good as the training received in traditional schoolhouses. While government studies of the Navy's CBT training confirmed that the transition to CBT resulted in shorter training times and cost savings, sailors reporting to the Fleet were not as well prepared as classroom-trained sailors of the past and extensive OJT, supervision, and assistance in performing basic maintenance tasks were required to bring CBT-trained sailors up to speed.

This study looked at costs from a systems perspective, considering not only the cost of training but also at the cost of maintenance. We asked the question: If sailors trained with CBT had lower knowledge and skill levels, did this contribute to increased operations and maintenance costs?

Unfortunately there were too many confounding variables that could have affected O&M costs during this period of time to draw any conclusions about the effect of CBT on maintenance costs from the Navy level. Instead, we focus on a single Navy system, the AN/SQQ-89(v) sonar system, to examine the effects of the conversion to CBT on maintenance. Controlling for the navy's planning for manning the system, the number of billets authorized, and the number of personnel on board, we find that CBT adversely impacted costs, actions, and maintenance hours. These findings provide, for the first time in the literature, empirical evidence CBT's negative impacts, including rising Fleet maintenance costs.

While it seems reasonable that CBT may lower costs and maintain quality for relatively simple tasks, it may not be as effective for specialized, knowledge-intensive skills. Future research should explore whether CBT has affected other systems in a similar manner. This question is of direct policy and financial interest to the navy; navy expenditures may rise from increases in costs and actions.

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