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ABSTRACT

The research reported here examines overall training effectiveness for U.S. Naval personnel; the measure of effectiveness comes from the survey responses of the supervisors of first-term enlisted Naval personnel. These supervisors were asked about the productivity of "typical" first-term personnel who were schooled in the classroom or trained on the job. The survey is the Enlisted Utilization Survey (EUS) conducted by the RAND Corporation for the Department of Defense in the mid-seventies. The EUS included over 2,000 supervisors' productivity assessments for twelve Navy occupational categories: seven of the specialties offer the alternative of formal schooling or on-the-job training. For five of the specialties, only formal classroom training is used. Overall, these specialties characterize a broad cross-section of Navy jobs that vary considerably in technical complexity and formal school length.

The data permit us to estimate learning curves (the growth of productivity or effectiveness) for both training methods. The measure of effectiveness is the net productivity of the "typical" trainee, that is, the contribution of the trainee minus the loss in production of experienced personnel who must supervise and train him. (This is the implicit cost of on-the-job training.) For the cost of formal schooling, we used Navy administrative data. Information about the performance of the typical first-termer for both modes of training was available at four time periods: after 1 month, 1 year, 2 years, and 4 years at his first duty station. Comparisons are drawn between the two training methods. Finally, the usefulness of research on training effectiveness in other areas of military manpower research is discussed.

AN EVALUATION OF THE EFFECTIVENESS OF CLASSROOM AND ON-THE-JOB TRAINING

1. INTRODUCTION

The value of different methods of training military personnel depends on both their costs and effectiveness. Without such information, training methods and choices among them cannot be evaluated objectively. Given the importance of information on training costs and the subsequent effectiveness of different training modes, the paucity of research is surprising. The reasons, however, are not difficult to uncover. First there is the difficulty of measuring the effectiveness of the training. Pen-and-paper or hands-on tests have been used to determine how well particular skills were learned, but there is little agreement on a metric for translating test scores into on-the-job effectiveness. Overall comparisons of competing training methods (conventional classroom instruction versus training done exclusively on the job) have been hampered by the difficulty of measuring effectiveness and by the difficulty of measuring training costs when training is done exclusively on the job. A substantial gap exists between the resources devoted to the training of military personnel and the resources devoted to evaluating that training.*

To help close this gap, the research reported here examines the effectiveness of training for U.S. Naval personnel, using data from the Enlisted Utilization Survey and from Navy administrative records. Using these sources, we assess the productivity of typical first-term Naval enlistees in 12 major occupational specialties, by occupation and type of training, at four points in time. We also construct cost estimates for the two training modes.

After estimating effectiveness growth curves, we construct indices for the fraction of an average careerist's output (for each specialty and training mode) produced by first-term individuals. Finally we integrate information on formal schooling costs with the effectiveness data, and compare the cost effectiveness of the alternative training methods.

2. MEASURING THE EFFECTIVENESS OF TRAINING

An issue frequently confronted by military manpower analysts is the relative effectiveness of first-term and career personnel. Similarly, there are questions about the efficacy of the different methods of training recruits. To address such concerns, one needs to

* For an example of some important earlier work and a discussion of the difficulties in obtaining robust estimates, see [1].

quantify the relative effectiveness of individuals in different categories, whether the categories be recruits trained by different techniques or first-termers versus more experienced military personnel.

Quantification of productivity or effectivenesss is complicated by the fact that individuals within any particular occupation perform many tasks: an individual may excel at some of these tasks but perform others less well. Summary measures of overall effectiveness are required, however, if unambiguous comparisons are to be drawn across different training modes. In this paper we have chosen personnel assessments made by supervisors as our measure of overall effectiveness. In particular, we use supervisors' responses from a survey conducted by the RAND Corporation for the Defense Advanced Research Projects Agency. Let us now turn to a discussion of this survey.

2.1 The Enlisted Utilization Survey (EUS)

The EUS surveyed first-term personnel at their first duty station between November 1974 and January 1975 in 58 Army, Navy, and Air Force occupational specialties.* The survey was done in two parts. The first questionnaire went to enlistees, asking for some background information and the names of up to three immediate supervisors. The second questionnaire went to the identified supervisors, seeking productivity information on the recruit and some background information on the supervisor. The responses to the two questionnaires were then merged with individual personnel files from the appropriate service.

Here we analyze only those EUS data that pertain to the Navy.** For Naval personnel, there are over 2,000 supervisors' productivity assessments for 15 Navy occupational categories. The 15 occupational categories cover about 50 percent of Navy enlisted personnel. Three of the categories, however, comprise general-duty personnel for which no training (other than initial recruit training) is provided; enlistees in these specialties will be discussed in a

* See [2], [3], and [4] for a detailed discussion of these data and of the usefulness of survey data in general.

** Although the RAND researchers focused on the Air Force personnel data, they provided descriptive statistics for the overall sample; the Navy data, however, were never extensively analyzed.

separate report.* Seven of the occupations offer a choice of training methods--formal schooling (A-school) or on-the-job training (OJT). Training for five of the jobs is done only in school (three of these jobs are in the nuclear power area). Overall, the occupations we analyze cover a broad cross-section of Navy jobs that vary considerably in technical complexity and length of formal schooling.

The EUS asked supervisors to rate the net contribution to output of first-term individuals at several points within the first enlistment term. The productivity assessments are all relative to an average specialist with 4 years of experience in that occupation. In this paper we focus on supervisors' assessments of the effectiveness of "typical" individuals in each training path; the assessments are at four different points during the first enlistment term. Our particular focus is Navy occupations for which training can take place either exclusively on the job or through a combination of formal schooling and on-the-job training.

2.2 The Growth of Productivity in the First Term

The EUS questionnaire distributed to supervisors asked the respondents to rate the relative productivity of typical first-term enlistees in their occupation 1 month after arriving at the first duty station. Separate questions were asked about the relative productivity of a typical graduate from A-school and a typical direct-duty assignee.**

The survey attempted to assess net productivity of the trainee, that is, the contribution of the trainee minus the loss in production of experienced personnel who must train and supervise him. At the 1-month point, the trainee's net contribution to unit output is often

* Productivity results for Airmen, Seamen, and Firemen (who do not achieve or "strike for" a specific occupation) are not analyzed in this paper, which focuses on the growth of productivity for individuals who become occupationally qualified petty officers during the first 4 years. It should be understood, however, that a discussion of the product. ity of a typical on-the-job-trained petty officer involves a period of time when he was not occupationally designated (a non-designated striker). The promotion steps for an Aviation Machinist's Mate (AD), as an example, entail being advanced to Airman (AN), then becoming a designated striker (ADAN), and finally being promoted to the occupationally qualified level, petty officer third class (AD3).

** Other work by the authors analyzed survey results for individual recruits. This paper, however, focuses on the supervisors' responses to questions concerning the "typical" recruit.

negative.* Performance of a trainee was also evaluated after 1 year, 2 years, and 4 years at a duty station.

In particular, for A-school graduates, the questionnaire asked the supervisor to "estimate the typical new 'A' school graduate's NET CONTRIBUTION TO UNIT PRODUCTION at several points in his service career, assuming he serves 4 years or more in this shop or section. An individual's NET CONTRIBUTION TO UNIT PRODUCTION is his direct production minus production lost by others who supervise and instruct him." The assessment was further directed to be "relative to the average specialist with four years experience."

The averages of the supervisors' responses (for each of the four points in time) are presented in table 1. First, the results are shown for occupations that have alternative training paths. Next, results are reported for occupations trained exclusively in A-school (three nuclear power fields and two medical specialties).

The general results of table 1 are in accord with our expectations. First, in all occupations average productivity grows over time. Second, in occupations that offer alternative training paths, the productivity of A-school graduates exceeds that of those learning exclusively on the job. Since A-school graduates have spent 142 to 468 days in the classroom learning the required skills before they arrive at their duty station, a different result would be surprising. Third, the typical OJT trainee never reaches the 4-year average specialist level. Although this result is not inevitable, it is plausible: the dominant training mode used by the Navy for these specialists is A-school. Finally, average productivity after 4 years at the duty station is approximately 100 percent for A-school attendees. Since the productivity estimate is inherently normed—the typical enlistee in the specified training path relative to the average fourth-year specialist—this result again conforms to expectations.

Results for three Navy occupations—Electricians' Mates (EMs), Machinists' Mates (MMs) and Aviation Electricians' Mates (AEs)—are presented in figures 1, 2, and 3. The illustrations make a clear point of how much of the first enlistment period is spent learning.

The productivity estimates presented in table 1 are point-in-time estimates. To convert these estimates into a continuous measure

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* The advantages of having a measure of net, rather than gross, productivity are enormous. Without a measure that includes the loss of productive time by supervisory personnel, it would not be possible to calculate the cost of on-the-job training. In short, cost-benefit comparisons of the two training modes would not be possible.

TABLE 1

NET PRODUCTIVITY OF A TYPICAL ENLISTEE OVER TIME

Occupations with either classroom (A-school) or on-the-job training mode

Time at first duty station	Mess Management Specialist (MS)[a]			Aviation Machinist's Mate (AD)			Machinist's Mate (MM)		
	Net productivity			Net productivity			Net productivity		
	A-school	Direct duty	t test	A-school	Direct duty	t test	A-school	Direct duty	t test
1 month	2.06	-15.76	6.04	-13.85	-39.26	5.62	-17.01	-31.21	7.53
1 year	44.46	29.35	6.09	41.76	21.72	4.05	34.22	20.24	9.50
2 years	70.70	59.43	5.05	73.55	56.71	5.01	65.68	53.28	9.70
4 years	94.65	89.67	2.25	99.44	86.74	3.67	96.02	88.63	7.40
Days of training before first duty station	117	75		131	75		135	75	

Time at first duty station	Radioman (RM)			Electrician's Mate (EM)			Electronics Technician (ET)		
	Net productivity			Net productivity			Net productivity		
	A-school	Direct duty	t test	A-school	Direct duty	t test	A-school	Direct duty	t test
1 month	-18.52	-41.59	9.73	-8.17	-35.11	16.50	-19.81	-43.70	11.54
1 year	42.28	21.21	10.24	41.65	14.87	19.40	41.43	13.23	13.16
2 years	71.61	55.23	9.52	70.98	46.92	19.51	72.37	46.84	13.82
4 years	97.04	88.15	6.22	98.20	80.89	15.18	97.63	78.32	12.70
Days of training before first duty station	153	75		175	75		330	75	

NOTE: t statistics are provided for tests of the equality of means. The hypothesis that the means are equal is rejected in every case; for a one tailed-test, the critical values are $t > 1.64$ (reject at the 5-percent level) and $t > 2.33$ (reject at the 1-percent level).

[a]In 1974, at the time of the EUS Survey, this rating was called Commissary Specialist (CS).

TABLE 1 (Cont'd)

Time at first duty station	Aviation Electrician's Mate (AE): Net productivity, A-school	Aviation Electrician's Mate (AE): Net productivity, Direct duty	Aviation Electrician's Mate (AE): t test	Occupations trained only by A-school: Dental Technicians (DT), Net productivity	Occupations trained only by A-school: Hospital Corpsman (HM), Net productivity
1 month	-25.88	-51.81	4.96	14.36	-7.90
1 year	34.06	7.74	4.80	64.15	51.20
2 years	70.19	46.27	4.68	84.04	79.15
4 years	101.27	83.74	3.78	100.30	100.40
Days of training before first duty station	198	75		159	146

Time at first duty station	Occupations trained only by A-school — Submarine nuclear power occupations: Machinist's Mate, Net productivity	Electrician's Mate, Net productivity	Electronics Technician, Net productivity
1 month	-25.97	-16.53	-25.20
1 year	30.04	42.80	42.41
2 years	62.00	74.91	76.25
4 years	92.90	98.97	99.91
Days of training before first duty station	348	388	543

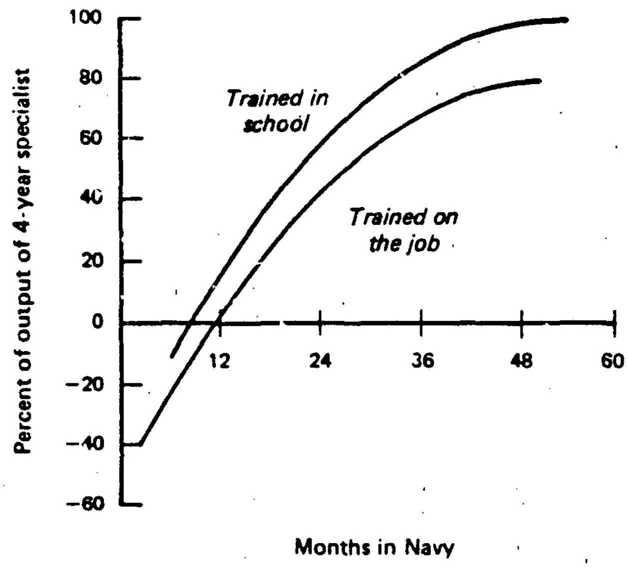

FIG. 1: PRODUCTIVITY GROWTH FOR ELECTRICIANS' MATES IN THE FIRST TERM

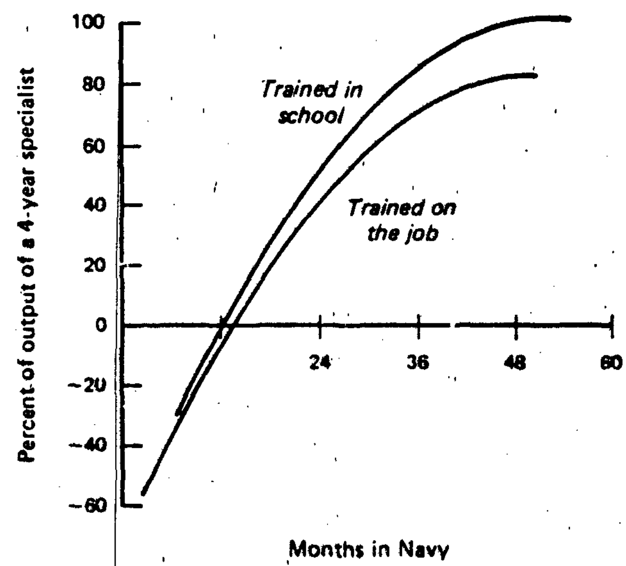

FIG. 2: PRODUCTIVITY GROWTH FOR AVIATION ELECTRICIANS' MATES IN THE FIRST TERM

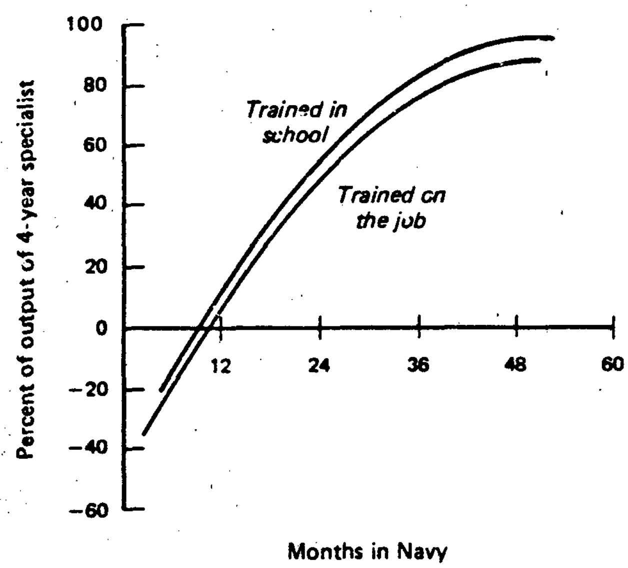

FIG. 3: PRODUCTIVITY GROWTH FOR MACHINISTS' MATES IN THE FIRST TERM

of productivity growth over time, the following equation was estimated for each occupational specialty:

$$NP = a + b_1t + b_2t^2 \quad .$$

NP is the value of net productivity and t is the time, in months, at the duty station.* The regression results by rating and by training type are reported in appendix A.

The average productivity values and the estimated regression coefficients provide information about the value of a first-termer, but there are too many numbers to facilitate easy comparisons across training modes. The next step, therefore, is to develop a single measure of effectiveness or productivity for each training mode. As our aggregate measure, we use the value of a first-term recruit

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* In the regressions, time is measured as months at the duty station (not time in the Navy). This procedure was computationally simpler.

relative to the value of an average specialist with 4 years of experience. The following section describes the two indices we constructed.

3. INDICES OF FIRST-TERMER PRODUCTIVITY

Here we want to construct indices that measure the productivity of typical first-termers relative to the productivity of trained specialists. Our definition of a trained specialist comes from the EUS questionnaire, namely 4 years of work experience in the specialty. The first index is the average fraction of the output of a trained specialist that is produced during the first 4 years in the Navy. Graphically, it is the shaded area in figure 4 (minus the hatched area where net productivity is negative).

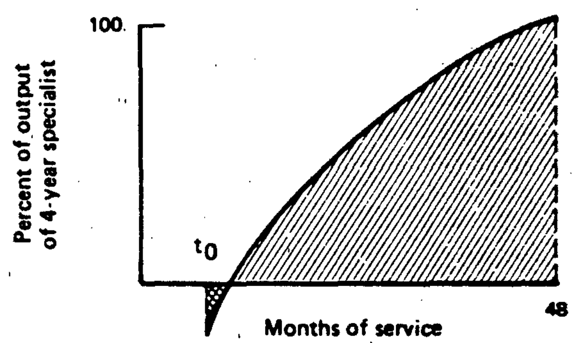

FIG. 4: HYPOTHETICAL MEASUREMENT OF FIRST-TERMER PRODUCTIVITY

More formally,

$$I_1 = \left[\int_{t_0}^{48} P(t)dt\right]/48 ,$$

where

t_0 is the month of arrival at first duty station.

P(t) is productivity at time t. (Productivity is measured as the fraction of the output of a fourth year specialist that is produced.)

This index allows comparisons of relative productivity during the first 4 years for different training modes within an occupation. Additionally, it allows comparisons across different Navy occupations; here it facilitates understanding of how much of the first term is spent in "learning" and how much is spent in "doing" for the different Navy jobs.

The second index differs in that it looks at the relative productivity for 4 years after arrival at the first duty station. Since first-termers in different occupations (or in different training paths within an occupation) spend different amounts of time in training before arriving at their first duty station, this index is not quite so convenient for comparison across occupations. Specifically, the formula for the second index is:

$$I_2 = \left[\int_{t_0}^{t_0 + 48} P(t)dt\right]/(48 + t_0) \quad .$$

The advantage of this index, however, is that it utilizes all the information in the questionnaire: namely, the growth of productivity for 4 years after arrival at the first duty station. Since the second index measures productivity over a longer time, capturing more productive time, it is always larger than the first index.* Except for the nuclear power occupations (in which training time is very long), both indices order the jobs in a similar fashion.

The resulting relative productivity assessments for A-school graduates are presented in table 2. For Electronics Technicians, for example, typical A-school graduates average (over the 4-year period) 41.5 percent of the output of a 4-year specialist's output during 4 years. If we look at their output over the longer period encompassed in the second index, they produce 51.7 percent of the output of a specialist with 4 years of experience. Here we are looking at a period of over 5 years; supervisors evaluate the average output of two first-termers during this period as roughly equivalent to the output of one experienced individual.

For the seven relevant occupations, table 3 contrasts the A-school and OJT training paths. Not surprisingly, A-school graduates generate more net output over the first 4 years than those trained solely on the job. These comparisons, however, are somewhat misleading. They account for the full cost of training only for those trained exclusively on the job. (For these trainees the cost is the output foregone because of supervisory time; our productivity measure accounts for these costs.) For those trained in A-school, however, we do not yet include any estimates of the formal schooling cost. In the next section, we will provide comparisons that take into account the costs of formal schooling.

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* Four years at the duty station implies from 50-1/2 to 64 months in the Navy (the latter is for nuclear-trained Electronics Technicians; see appendix B).

TABLE 2

PRODUCTIVITY OF FIRST-TERM A-SCHOOL GRADUATES RELATIVE TO 4-YEAR SPECIALISTS

	Percent of output of 4-year specialist produced by first-termers	
Non-nuclear occupations	Index 1	Index 2
ET	41.5	51.7
AE	45.7	52.7
MM	47.8	52.3
EM	49.8	55.6
RM	51.9	56.5
MS	55.9	58.4
AD	55.5	60.2
HM	59.6	63.6
DT	66.5	69.9
Nuclear power occupations		
ET	29.6	48.2
MM	32.0	43.4
EM	37.8	51.1

TABLE 3

PRODUCTIVITY OVER 4 YEARS:
COMPARISON OF A-SCHOOL AND OJT TRAINING PATHS

Occupations	Index 1	Productivity of A-school graduate relative to direct-duty assignee
ET (A-school)	41.5	1.22
ET (OJT)	34.0	
AE (A-school)	45.7	1.41
AE (OJT)	32.4	
MM (A-school)	47.8	1.16
MM (OJT)	41.2	
EM (A-school)	49.8	1.41
EM (OJT)	35.4	
RM (A-school)	51.9	1.24
RM (OJT)	41.9	
AD (A-school)	55.4	1.31
AD (OJT)	42.3	
MS (A-school)	55.9	1.17
MS (OJT)	47.7	

4. COST-EFFECTIVENESS COMPARISONS

The net productivity indices we constructed measured the fraction of an average 4-year specialist's output produced by individuals in the first term. Now, we want to integrate the information on the output of typical first-termers with information on their costs. Appendix B provides detailed information on the cost computation. All costs are for FY 1979 and in FY 1979 dollars.* The data on A-school costs came from the Navy's Training, Analysis and Evaluation Group (TAEG) [5] and are reported in [6]. A-school costs include both formal school costs and wage costs. They represent the cost of an A-school graduate in the appropriate course.** Wage costs after training are based on FY 1979 pay rates. The cost of boot camp, including wages to recruits, was estimated at $2,165 per recruit.

Table 4 details these costs. Personnel who train exclusively on the job cost $23,160 (in 1979 dollars) over a 4-year enlistment term.*** Recruits who attend a formal school program cost from $26,990 for Mess Management Specialist to $49,678 for Nuclear-Power Electronics Technicians.

The second column of table 4 reproduces the first productivity index from table 3 (an index of 66.5 for DTs means that in the first enlistment period a typical DT averages 66.48 percent of the output that would be produced by a fully trained specialist). The final column of table 4 computes cost-effectiveness ratios for average personnel in each category. These are most meaningful for the seven ratings in which there are two training paths. AEs, for example, cost $637 per unit of benefit for a typical A-school graduate and $714 per unit of benefit for a typical non-A-school graduate.

Although the results are somewhat mixed, our estimates indicate that for most occupations, graduates of formal schooling are more cost effective than those trained exclusively on the job. This is true even though those trained in schools have considerably higher explicit costs than those trained exclusively on the job. In short, the greater productivity of A-school graduates, even over this relatively short period, appears to make this training mode a better buy.

* Transforming Navy cost figures for individual courses into cost figures for occupational qualification is a non-trivial task; here we use data constructed for another study, [6].
** If, for example, 100 individuals begin the course but only 80 finish it, the schooling costs are spread over the 80 graduates.
*** Neither cost nor productivity information is discounted; we are analyzing steady-state alternatives.

TABLE 4

COST EFFECTIVENESS COMPARISONS FOR 4 YEARS OF SERVICE

	I Total cost (from table B-1)	II Effectiveness (Index 1)	III Dollar cost per unit of effectiveness (column I divided by column II)
Non-nuclear occupations			
MS (A-school)	$26,990	55.9	482
MS (OJT)	23,160	47.7	486
AD (A-school)	26,637	55.4	481
AD (OJT)	23,160	42.3	547
MM (A-school)	28,843	47.8	604
MM (OJT)	23,160	41.2	562
HM (A-school)	28,431	59.6	477
DT (A-school)	28,999	66.5	436
RM (A-school)	29,456	51.9	567
RM (OJT)	23,160	41.9	553
EM (A-school)	29,137	49.8	585
EM (OJT)	23,160	35.4	654
AE (A-school)	29,090	45.7	637
AE (OJT)	23,160	32.4	714
ET (A-school)	35,598	41.5	859
ET (OJT)	23,160	34.0	682
Nuclear power occupations[a]			
MM	43,055	34.0	1,264
EM	43,332	37.8	1,147
ET	49,678	30.6	1,623

[a]These occupations have an initial obligation of 6 years.

In two occupations, Radiomen and Machinists' Mates, on-the-job trainees are slightly more cost effective. Only for Electronics Technicians does the OJT training path really appear superior. This result, however, may reflect the fact that most ETs are 6-year obligors, and the 4-year period over which we evaluate benefits and costs is probably too short. Even though ETs trained in A-school are more productive than those trained on the job, the fact that the first year and a half is spent in formal schooling makes their productivity quite low until the fourth year. Therefore, for 6-year obligors (Electronics Technicians and the three nuclear power occupations) the calculations should be done over a 6-year period. Unfortunately, since the survey normed productivity data for the 4-year specialist, we do not have the information to make such calculations.

In a larger sense, focusing only on the productivity of first-termers may unfairly inflate the cost-to-benefit ratio for those trained in formal school programs. First, in addition to their explicit costs, these programs consume a considerable amount of time within the first term. Even though the formal schooling alternative for RMs, MMs, and ETs did not appear cost effective over the first 4 years, an 8-year time horizon might provide a different picture. To test this conjecture, additional data would be required. Indeed, we would suggest that there is a clear need for more extensive collection of these types of data, a point to which we return later in this paper. First, however, let us discuss the uses for findings like these on training effectiveness.

5. THE USEFULNESS OF THESE FINDINGS IN OTHER AREAS OF MANPOWER ANALYSIS

Findings on training effectiveness can be used to study many aspects of military manpower—occupational assignments, the timing of training, the length of initial enlistment contracts, and the relative value of accession and retention. Some of these applications have already been undertaken, some are forthcoming, and others await more detailed data. Because we believe it is critical to incorporate information on both training effectiveness and the time-path of learning into other areas of manpower analysis (some of which may at first appear quite distinct from training analysis), we shall discuss each of these topics in turn.

5.1 Occupational Assignments in the Military

One important problem faced by the U.S. military is the high rate of attrition within the first enlistment term. A study by Thomason [7] has suggested that first-term attrition could be reduced if better initial occupational assignment policies were followed. This study collected occupation-specific attrition rates for individuals in different age groups and education categories. Then, individuals were reassigned to occupations so as to maximize first-term retention; the overall gain in retention was about 10 percentage points.

Although Thomason's study made an important contribution to our understanding of personnel management, we believe that it is but a first step in analyzing efficient occupational assignment. The data that were available precluded using occupational assignment to maximize the cost-benefit ratio for the first-term cohort. Instead, the fraction of the original cohort that remained until the end of the first term was maximized (i.e., retention).

In Thomason's formulation, it is immaterial whether an individual drop out of the Navy just before formal schooling, or just after formal schooling, or with 1 day left on his first-term commitment: all of these individuals were identified as dropouts. Our data suggest that it makes a substantial difference when an individual leaves within the first term. Data on the costs of formal schooling given in appendix C suggest that several thousand dollars of savings are associated with attrition before, rather than after, attending the Navy's A-school program. Clearly there is a need to integrate cost-benefit data with attrition data if the Navy is to efficiently manage its occupational pipelines. A more ambitious effort in this area has the potential to produce considerable cost savings.

5.2 The Timing of Training

Another training issue is the question of the timing of training within an occupational category. In the U.S. Navy this usually involves questions about whether an individual should go directly from boot camp (recruit training) to occupational training school or whether he should first have some experience with the fleet. Fundamental to these discussions is the principle that if the individual is not suited to Navy life, it is better that he leave the Navy before the expenditure of training dollars.

Unfortunately, this is an area in which we have very litle data to analyze. We simply do not know how the timing of training affects attrition, or whether the current training pipeline patterns are efficient or not. Part of the gap results from the lack of data bases that integrate information on the timing of training with individual personnel files. It is extremely time-consuming (and expensive) to build such data bases; in our judgement, however, it is worthwhile to do so.

5.3 The Length of the Initial Enlistment Contract

Historically, the length of military contracts has varied widely. During the Revolutionary War, contracts for American militia men averaged less than 3 months; in contrast, the contracts for recruits in the British Navy are currently for 20 years, although an individual can give 18-months notice after a specified period has passe .

Before the advent of the All Volunteer Force in 1973, initial active-duty enlistment contracts averaged 2.8 years in the U.S.; currently the average is 3.7 years. While the majority of the contracts are for 4 years, in FY 1980, 7 percent of the contracts were for more than 4 years, and 39 percent were for less than 4 years. The Army has the shortest average contract, with over two-thirds of its initial contracts for 3-year periods. Only the Air Force and the Navy use initial contracts longer than 4 years. The Navy, of all the services, has the greatest variability in the length of an initial active-duty obligation, requiring enlistments of 5 or 6 years for occupational specialties with larger training components, and experimenting with 2- and 3-year contracts for general-detail sailors.

Against the backdrop of this variability in length of the initial enlistment period, there have been suggestions that the initial enlistment period be lengthened in all services [8]. Longer enlistment terms, of course, reduce the required number of yearly accessions and the number of individuals who must be trained. Longer contracts generate cost savings by reducing instructional cost and releasing personnel and equipment from instructional tasks.

Clearly, however, it is not costless to extend the enlistment period. To make a longer contract attractive, even if required accessions are reduced, probably involves an increase in military pay. Indeed, the proposal only makes sense if the required pay increases are smaller than the savings achieved by having to train fewer individuals. For military occupations with short training times, cost savings will be small. Similarly, occupations with long training times will achieve larger cost savings if fewer recruits need to be trained. The observation that cost savings will vary across occupations suggests it is unlikely that all military occupations should have the same contract length. In fact, the current variety in the length of the initial active-duty enlistment appears to reflect differences in training costs: occupations with smaller training components have shorter contracts than those with larger training components.

How, then, have current contract lengths been set? Have enlistment lengths been systematically established so that military output is obtained at least cost? Given the importance of the issue and the variety in initial contract periods, there is surprisingly little rigorous analysis.

Available data can be used to evaluate current first-term contract lengths and to estimate the effects on cost and output of changes in the contract period. Some assumptions will have to be made because existing data do not allow empirical estimation of all the important variables. However, existing information should permit a worthwhile examination of the costs and benefits of varying first-term enlistment lengths. Such an effort is underway [9, 10].

5.4 Accession Versus Retention

One problem that the U.S. Navy has faced for many years is a shortage of mid-career petty officers. There are two principal ways to alleviate this shortage: recruit more personnel initially or encourage more personnel to stay. The first strategy entails an increased number of recruits with associated increases in recruiting and training costs. The second strategy involves larger expenditures on bonuses or careerists' base pay to encourage trained individuals to remain with the Navy. Both strategies cost money. The question is which—or what mix—of the two strategies eliminates the shortage of petty officers at least cost. Moreover, since the two strategies involve different mixes of careerists and recruits, the strategies may have different implications for the effectiveness of the force. Indeed, our findings suggested that first-termers are considerably less productive than specialists with 4 years of experience.

Several other efforts at the Center for Naval Analyses have addressed these questions [11, 12]. Overall, policies directed toward increased retention have been found to be the most efficient method for alleviating the petty-officer shortage: costs of first-term pay, recruitment, and training were considerably larger than the expenditure (via reenlistment bonuses or increases in the base pay of careerists) necessary to improve retention.

6. CONCLUDING COMMENTS

The U.S. military provides a considerable amount of training to its personnel. Much of this training is formal and takes place in the classroom, while the remainder is informal and takes place on the job. We have adequate information on the costs of formal training (although there is a clear need to maintain the type of data bases required to carry out the ambitious research agenda outlined earlier). Where our basic information is inadequate is in the area of estimating costs of training done on the job. This paper has discussed one such effort (the EUS survey). We used the supervisors' responses to compare the costs and benefits of formal schooling and on-the-job training.

In general our analysis of the supervisors' answers in the survey provided very plausible information on the effectiveness of training. Our major caveat is that the survey design normed the effectiveness measure at the level of the 4-year specialist; to the extent that learning continues after 4 years, and particularly if it continues at different rates for the two training modes, our conclusions might be different. For such an investigation, however, more data need to be collected. We believe that an effort to collect supervisory assessments on both first- and second-term personnel would be worthwhile.

In summary, to answer questions about how the military should train its personnel and how it should mix trained and newly recruited personnel, much more research on training effectiveness is needed. If we are to address effectiveness questions with the degree of sophistication with which we address recruitment and retention questions, we need to think very hard about what data we need and whether experimental data are required. A substantial research agenda remains.

7. REFERENCES

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APPENDIX A

REGRESSION COEFFICIENTS:
THE GROWTH OF PRODUCTIVITY OVER 4 YEARS
AT THE FIRST DUTY STATION

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REGRESSION COEFFICIENTS:
THE GROWTH OF PRODUCTIVITY OVER 4 YEARS
AT THE FIRST DUTY STATION

Table A-1 provides regression estimates for the growth of productivity over time. Separate estimates are given for each of the 12 Navy occupations examined.

TABLE A-1

REGRESSION COEFFICIENTS: THE GROWTH OF PRODUCTIVITY OVER 4 YEARS AT THE FIRST DUTY STATION

	Mess Management Specialist (MS)		Aviation Machinist's Mate (AD)	
	A-school	Direct duty	A-school	Direct duty
Constant	-1.09	-19.30	-17.72	-45.46
Months	4.14	4.42	5.39	5.89
Months squared	-.045	-.045	-.062	.066

	Machinist's Mate (MM)		Radioman (RM)	
	A-school	Direct duty	A-school	Direct duty
Constant	-20.70	-34.97	-21.83	-45.27
Months	4.96	4.96	5.67	5.94
Months squared	-.053	-.050	-.067	-.067

	Electrician's Mate (EM)		Electronics Technician (ET)	
	A-school	Direct duty	A-school	Direct duty
Constant	-11.62	-38.77	-23.44	-47.64
Months	4.80	4.82	5.79	5.48
Months squared	-.052	-.049	-.068	-.060

	Aviation Electrician's Mate (AE)	
	A-school	Direct duty
Constant	-30.26	-56.37
Months	5.85	5.82
Months squared	-.065	-.061

TABLE A-1 (Cont'd)

	Dental Technician (DT)	Hospital Corpsman (HM)	Nuclear power occupations: Machinist's Mate	Electrician's Mate	Electronics Technician
Constant	12.24	-11.17	-29.63	-20.48	-29.33
Months	4.51	5.54	5.33	5.73	6.46
Months squared	-.056	-.067	-.058	-.068	-.079

NOTE: In the regression, months are measured as months at the duty station. Since enlistees in the different occupations train for different amounts of time before arriving at the duty station, it would be misleading to directly compare the regression coefficients across the occupations. For example, Nuclear-Power Electronics Technicians have been in the Navy 18 months before they arrive at a duty station (versus 2.5 months for direct-duty Electricians' Mates).

APPENDIX B

PIPELINE COST CALCULATIONS

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PIPELINE COST CALCULATIONS

This appendix details the procedure followed to compute A-school costs. All data are for FY 1979 (pay table in effect 1 October 1978). The training data are derived from the Navy's Training Analysis and Evaluation Group (TAEG) and include the costs of formal training and wages. All personnel are assumed to progress in pay grade at the same rate: average pay grades are 1.81, 2.76, 3.51, and 3.98 for the first 4 years, respectively. The lengths of individual courses and their costs, calculated from FY 1979 TAEG data, can be found in [6].

Some occupations have parallel training pipelines. If there was not a dominant pipeline, we constructed average training costs by weighting the costs of the parallel courses by their enrollments. For example, Machinists' Mates take either Course Data Processing (CDP) Code 6492 or 6493 for the final course in their training sequence. In FY 1979 there were 2,414 enrollments in CDP 6492, and 2,394 enrollments in CDP 6493. Costs (lengths) were $1,301 (39 days) and $989 (29 days), respectively. The average cost and length of the final course in the Machinist's Mate sequence is thus computed as follows:

$$\text{Average cost} = \frac{2414}{4808}(\$1301) + \frac{2394}{4808}(\$989) = \$1145$$

$$\text{Average length} = \frac{2414}{4808}(39) + \frac{2394}{4808}(29) = 34 \text{ days}$$

Aviation Machinists' Mates have 17 parallel courses: here we used the dominant pipeline course. For Electronics Technicians, however, the four parallel first courses display relatively even enrollments; thus, in this case we weighted both the costs and course lengths by the enrollments.

Data for each occupation examined are given in table B-1.

TABLE B-1

PIPELINE COST CALCULATIONS

Direct-duty personnel (trained exclusively on the job)

Occupations	Boot camp: Length (days)	Boot camp: Cost[a] ($)	Wages after boot camp	Total cost for 4 years
All occupations for which training can be done exclusively on the job: AD, AE, EM, ET, MM, MS, RM	75	2,165	$23,160	$25,325

Personnel trained in the classroom (A-school)

Non-nuclear occupations	Boot camp: Length (days)	Boot camp: Cost[a] ($)	Formal schooling: Course (CDP)	Formal schooling: Length (days)	Formal schooling: Cost[a] ($)	Wages after formal schooling	Total cost for 4 years
Mess Management Specialist (MS)	75	2,165	6125	42	2,337	$22,488	$26,990
Machinist's Mate (MM)	75	2,165	601G	4	1,461		
			6262	22	1,830		
			6492} 6593}	34	1,145		
				60	4,436	$22,242	$28,843
Aviation Machinist's Mate (AD)[b]	75	2,165	6297	2	100		
			6210	12	452		
			6501	42	1,617	$22,303	$26,637
				56	2,169		

[a]This cost includes wages.
[b]The AD rating has 17 parallel pipelines. Sixteen of these pipelines were very small in 1979, and over 80 percent of the ADs trained through the pipeline indicated. Thus, in this case, our cost estimate is of the dominant training pipeline.

TABLE B-1 (Cont'd)

Non-nuclear occupations	Boot camp Length (days)	Boot camp Cost[a] ($)	Formal schooling Course (CDP)	Formal schooling Length (days)	Formal schooling Cost[a] ($)	Wages after formal schooling	Total cost for 4 years
Radioman (RM)	75	2,165	6144	56	3,961		
			6380	22	1,363	$21,967	$29,456
				78	5,324		
Aviation Electrician's Mate (AE)	75	2,165	6297	2	100		
			6218	9	339		
			6235	35	1,525		
			6515	77	3,683	$21,278	$29,090
				123	5,647		
Electrician's Mate (EM)	75	2,165	6258 / 6273	54	2,662		
			6070	46	2,680	$21,630	$29,137
				100	5,342		
Electronics Technician (ET)	75	2,165	6414 / 6409 / 6417 / 6412	64	3,140		
			6420 / 6428	191	1,1034	$19,259	$35,598
				255	1,4174		
Hospital Corpsmen (HM)	75	2,165	6084 / 6085	71	4,192[c]	$22,074	$28,431
Dental Technician (DT)	75	2,165	6086	84	4,959[c]	$21,875	$28,999

[c]Our best estimate of the cost of formal schooling is $59.07 per day. The TAEG data base did not include medical specialties.

TABLE B-1 (Cont'd)

Nuclear occupations[d]	Boot camp and formal schooling prior to nuclear power training: Length (days)	Cost[e] ($)	Nuclear power training: Course (CDP)	Length (Days)	Cost[e] ($)	Wages after training	Total cost for 4 years[e]
Machinist's Mate	135	6,601	130D	42	1,602		
			130E	171	15,869	$18,983	$43,055
				213	17,471		
Electrician's Mate	175	7,507	130D	42	1,602		
			130E	171	15,869	$18,354	$43,332
				213	17,471		
Electronics Technician	330	16,339	130D	42	1,602		
			130E	171	15,869	$15,868	$49,678
				213	17,471		

[d]Individuals in these occupations must first receive the training for the non-nuclear portion of the occupation. For example, Machinist's Mates (Nuclear Power) must first go through boot camp and the MM sequence enumerated above.
[e]All nuclear power occupations have a 6-year initial enlistment term.

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