What is a Pound of Training Worth? Frameworks and Practical Examples for Assessing Return on Investment in Training[1]

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ABSTRACT

Effective training can provide the military with the edge it needs to operate successfully, win wars, and save lives. Yet, properly assessing the degree to which training is effective is a complex process, involving measures of learner performance, measures of organizational impact as well as determinations of what tradeoffs must be made to develop, acquire, and maintain any training solution. Most training effectiveness assessments are conducted to determine the utility of adopting new, or at least different, instructional capabilities. In these cases 'utility' is measured in terms of metrics like reducing the time learners need to reach criterion performance or increasing learner performance while holding time constant. While these measures quantify whether or not learners have increased their knowledge, skills, and abilities beyond those of others trained differently and/or have done so more quickly, they do not quantify the impact such training will have on their performance in real world settings nor how such performance will impact the organization of which they are a part. Consequently, these measures do not provide decision makers with the information they need to adequately assess tradeoffs in committing long-term funding, personnel, and infrastructure resources to a particular training capability or to training itself. Their decisions require more comprehensive analyses that assess the long-term impact of potential training capabilities, combined with a wider set of metrics that account for research and development investments, equipment purchases, equipment maintenance costs, learner and instructor time, follow-on sustainment, and on the job training. In this paper, we address this gap by developing an approach based on learning and economic theory for assessing return on investment and thereby obtaining measurement information needed for these analyses. Frameworks and examples applying this approach to evaluations of training systems are provided.

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INTRODUCTION

Admiral Isaac Kidd, retired head of Naval Materiel Command and chair of several Defense Science Board panels, often challenged the human performance community by asking, "What is a pound of training worth?" The question highlights an issue that high-level Defense planners continue to face. Should they, for example, buy a pound of training, a pound of jet propulsion fuel, or a pound of munitions? They could, with some precision, estimate how much more flying time the fuel would provide and the expected number and type of targets hit using different munitions. But how might they relate training to system and operational effectiveness? Many decision makers are willing to take the value of training and human performance on faith, but faith only goes so far when resources are limited and budgets are tight.

Training's purpose in the military and elsewhere is to enhance the human performance needed for successful operations. Defense decision makers need information that balances investments in training against other, competing alternatives for enhancing operational effectiveness – as well as for selecting among training alternatives themselves. For that reason, we have been exploring analysis techniques that help answer Admiral Kidd's question. When we ask what a pound of training is worth, we are asking what a pound of expertise in the field is worth, and how much it costs to get it.

Interest in cost assessment, which began in the manufacturing sector, has now worked its way through the service, health care, and public sectors, has finally arrived at education and training (Phillips, 2003). It seems time to address this issue directly for military training. We do so by drawing on learning and economic theory to establish assessment frameworks to better inform these decisions. We provide examples applying these frameworks to develop Return on Investment (ROI) ratios and Net Present Value (NPV) assessments. Before turning to these frameworks and their illustrative examples, a brief perspective on cost analysis is in order.

COST ANALYSIS AND TRAINING

Allocating resources among competing alternatives is a perennial necessity in administrative decision-making (Simon,1997). The hallmark of such decision-making is not just identifying promising opportunities but determining what must be given up to take advantage of them. These decisions typically involve formal processes for identifying the trade-off space, such as the "standard economic model" or the "rational theory of choice" (Keeney & Raiffa, 1976; von Neumann & Morgenstern, 1944). These models assess alternatives by balancing the expected (what's the probability of success?) and weighted (if successful, how much difference would it make?) utility of each alternative against its projected costs, consequences, and constraints. The problem on which these models focus is one of optimizing a range of options, not simply maximizing the impact of any single option. Underlying these models are assumptions that include the well-established notion that there is no free lunch, that there exists a combination of resources that maximizes productivity (e.g., operational effectiveness) with minimum (not minimal) resources, and that it is the job of analysis and decision-making to find it.

Accurately representing cost is a critical factor in these models. 'Cost' may be measured in a variety of ways, but the single most accessible and acceptable measure of cost remains monetary units, dollars for instance. Decisions in these cases key on dollars returned for dollars invested – costs, effectiveness, and cost-effectiveness are all at issue. Even with these data, the decisions do not make themselves. Other factors come into play. Especially in the military, the closer we come to armed conflict, when human lives enter into serious harm's way, the more likely it will be that training effectiveness will outweigh cost in making final decisions. Our purpose is to suggest ways to develop objective cost analyses as a basis for deciding among alternative investments for enhancing operational effectiveness. These techniques rarely produce optimal solutions, but they can contribute significantly to 'satisficing' solutions that satisfy and suffice to meet current needs (Simon, 1956).

Although rare, efforts have been made to develop methods to assess the contributions training, and the resulting competencies it enables, brings to operational effectiveness. Notable among these is a comprehensive design decision aid -- the Army's Optimization of Simulation-Based Training Systems (OSBATS) (Singer, 1993). OSBATS is a rule-based 'expert' system using historical cost and benefit data to analyze tradeoffs among specific features that might be included in a training device or simulator. OSBATS provides device configurations and fidelity features that will produce specified training objectives given specified cost thresholds for development. Although Singer (1993) reported substantial agreement between OSBATS design recommendations and those of subject matter experts, Willis (1990) found that some of its recommendations may be prohibitively difficult to implement.

Other types of design decision aids focus less on quantifying specific design-cost tradeoffs and more on qualifying the role the proposed system would play in the overall training pipeline. For example, the Air Force Automated Simulator Test and Assessment Routine (ASTAR) (Rose, Martin, & Wheaton, 1988) and Relating Effective Learning to Attributes of the Training Environment (RELATE) (Estock, McCormack, Bennett, & Patrey, 2008) have made important strides in developing effective procedures to link training design to achieving training objectives and human performance levels. While these and other design decision aids provide guidance that may increase the cost-effectiveness of training, they do not explicitly incorporate monetary cost variables in making their recommendations.

OVERVIEW AND ORGANIZATION

Cost analysis is as subject to controversy as other assessments. Differences in data, data definitions, analysis techniques, models, and assumptions are as likely to be found among cost analyses as elsewhere. Training system decision-makers would be well served by the adoption of generally accepted practices for cost element definitions, data models, and techniques. Analysts have suggested models with practicable, well-defined cost elements for use in training cost analyses (e.g., Knapp & Orlansky, 1983), but, with the scarcity of such analyses being performed, these models are rarely noted, heeded, or used.

Just as there are many different factors underlying cost analysis, so too there are many different approaches underlying effective training. We focus on training approaches that collapse time to achieve expertise and assess the expected return on training investments from such solutions. In some cases these investments may compress the many years of experience needed to produce expertise into a matter of months. Doing so should act as a force multiplier by releasing more qualified individuals sooner from the training infrastructure for active duty assignments.

First, we outline the framework for conducting a general training system cost effectiveness analysis. We then provide two examples to illustrate the framework and the return on investment (ROI) methodology they employ. The first example considers the straight-forward ratio of net return over costs within a single time period for a training system that compresses time to train. The second example considers the net present value (NPV) of investments in a system that not only compresses time to train but also raises the level of technical capability produced.

COST EFFECTIVENESS ANALYSIS FRAMEWORK

Training and education are more often viewed by the military as infrastructure expenses than investments. Yet, the direct and substantial contributions of human performance to system and operational effectiveness suggest that education and training might better be characterized as investments. A number of commentators have provided steps to use in performing cost-effectiveness analysis for training investments (e.g., Fitzpatrick, Sanders, & Worthen, 2003; McDavid & Hawthorn, 2005; Mishan & Quah, 2007; Phillips, 2003). In general, these steps include:

Identifying the Objectives

An analysis must be performed to identify and define what objectives the proposed training system is meant to achieve. These objectives may be expressed in terms of what students know and/or can do once they finish a course of learning. Other objectives and considerations may also apply. These objectives then provide a basis for interpreting any cost-effectiveness findings reported.

Identifying Requirements for Scale

Different decision-makers will have different scales of application in mind for the proposed training system. Scale may be considered in terms of annual trainee throughput, integration with existing infrastructure, accessibility, and so forth. The scale of application assumed by the analysis in terms of time, budget, and productivity must be defined and explicated to bound the analysis.

Identifying the Cost-Model to be Used

The cost model and its elements are critical components of any cost analysis. The cost model defines the costs to be included as explicitly and unambiguously as possible. Typically, a cost model identifies one or more cost scenarios to assist in transforming resource data (e.g. number of students, amount of training material) into cost data. Actual rather than budgeted costs should be used wherever possible. Knapp and Orlansky (1983) developed a general cost model for military training covering initial investment ('set-up') and direct and indirect costs for operations and maintenance. It provides a useful starting point for developing a specific cost model.

Identifying the Alternatives

A cost-effectiveness analysis must include a realistic and comprehensive set of alternatives. What alternatives to consider is a matter for discussion and negotiation between analysts and the decision-makers who may consult the results of the analysis.

Designing the Analysis

Cost analyses may involve experiments specifically designed to collect data for the assessment (e.g., Ross, Barkaoui, & Scott, 2007) or simply take advantage of already-collected empirical data (e.g., Levin, Glass, & Meister, 1987). Analyses should incorporate rigorous experimental design principles and attend to hidden and/or qualitative outcomes.

Establishing Metrics

A test of the adequacy of measures selected in a cost-effectiveness analysis is to determine whether an instructional alternative could excel in most of the measures and still not be best on some intuitive level. These cost-utility issues could arise if, for instance, the analysis overlooks some concerns of the individuals or organizations making the investment or those benefiting from its returns.

Metrics Pitfalls

When developing metrics for the cost analysis, it is important that the analyst avoid some common pitfalls. Significant pitfalls listed by Kazanowski (1968) are:

1) The *ratio fallacy*, which involves mis-scaling the costs of the training system being considered. If the analysis deals with costs that differ substantially from those anticipated by decision-makers, then the magnitude of costs they expect must be taken into account.

2) The *interrelationship fallacy*, which assumes that the relationship between analysis variables is monotonic and linear. Especially for training variables, these relationships may be neither.

3) *Spillover effects*, which concern interactions among systems. Implementing a training system for one application domain may well, if not inevitably, affect the operation of other systems present or planned. Such interactions should be considered in designing the analysis and reporting its results.

Performing the Analysis

The analysis should employ data drawn from sufficient sample sizes, use designs appropriate for an experimental, quasi-experimental, or analytical approach, and cover both short term and long-term effects. It should be as methodologically correct as time, budget, and circumstances allow.

Performing a Sensitivity Analysis

Assumptions must inevitably be made about the variables on which the analysis is based. Assumptions might include (a) materiel costs (e.g., how long equipment will last), (b) monetary costs (e.g., the rate of inflation over the period covered by the analysis), (c) usage (e.g., the number of students who will use the instruction), and/or (d) the frequency of updates. Sensitivity analysis should allow decision-makers to see for themselves how robust the analysis is with variations in its underlying assumptions.

Reporting the Results

It is critical for decision-makers to know the strengths and limitations of an analysis. When the data are gathered, they should be tabulated in a form suitable for comparison and the assumptions underlying the analysis should be identified and described as explicitly as possible.

RETURN ON INVESTMENT FOR TECHNOLOGY-BASED INSTRUCTION

Return on Investment (ROI) is used when the metrics of investment and return must be expressed in different terms (e.g., dollars for investment but expertise or operational effectiveness for return). Such analyses can be found for both military (e.g., Orlansky & String, 1977) and non-military training and education (e.g., Ross, Barkaoui, & Scott, 2007).

As discussed by Phillips (2003), along with many others, the basic formula for calculating ROI is:

$$\frac{\text{Value of the result} - \text{Cost of the investment}}{\text{Cost of the investment}}$$

In brief, it is the net value of the investment (i.e., after the cost of the investment is subtracted out) divided by the cost of the investment, yielding net return for each unit of investment. ROI is usually calculated for some period of time, such as a year.

ROI is simply a ratio. Just as with temperature or weight, which represent how hot or heavy a thing is without assigning 'worth' to such measures, so too ROI does not indicate that an investment is or is not cost-effective. While ROI provides us with the input needed for making these cost-effectiveness comparisons, credible decision alternatives must be identified and defined. Despite common usage we need to specify cost-effective compared to what specific alternatives, which should also be subject to cost-effectiveness analyses.

Example 1: Return on Investment Ratio for Reduced Specialized Skill Training Time

The following example is provided to show how ROI considerations may be linked into a single assessment. The training under consideration is common technology-based instruction, which promises to reduce overall time to train without reducing overall training effectiveness.

Identifying the Objectives

One of the most stable findings in comparisons of technology-based instruction with conventional instruction using lecture, text, and experience with equipment concerns time-savings. Orlansky and String (1977) found that reductions in time to reach instructional objectives averaged about 54 percent in their review of 13 technology-based military training programs. Fletcher (2001) reported an average time reduction of 31 percent in six assessments of interactive multimedia instruction applied in higher education. Kulik, (1994) reported time reductions of 34 percent in 17 assessments of technology used in higher education and 24 percent in 15 assessments of adult education. Overall, it seems reasonable to expect technology-based instruction to reduce the time it takes students to reach a variety of objectives by about 30 percent.

Identifying Requirements for Scale

The DoD spends about $6.5 billion a year on residential, specialized skill training, which is the 'schoolhouse,' instruction individuals receive after basic, initial accession, training. It qualifies individuals for the many technical jobs (e.g., wheeled vehicle mechanics, radar operators, avionics technicians, medical technicians) needed to perform military operations successfully. Reviews and analysis suggest that with technology-based instruction it is reasonable to assume a scale in which training time is reduced by 30 percent for 40 percent of DoD specialized skill students. Based on the model developed by Angier and Fletcher (1991) for performing such analyses, doing so through any means would reduce costs for DoD specialized skill training by about 17 percent.

Identifying the Cost Model

What would it cost to render this training with technology-based instruction? According to the last published Military Manpower Training Report (2002), the average Specialized Training course length across all four Services was about 57 training days in length.[2] If that time were reduced by 30 percent, the average number of training days would be reduced to about 40. Assuming 8-hour days, that amounts to about 320 hours of technology-based training. About 357,700 officers and enlisted personnel completed Specialized Training in FY02. We assumed that would be about the same in FY09. Forty percent of that number amounts to 143,080 learners. In effect then, 320 hours of technology-based training would have to be produced and then delivered to 143,080 learners.

Identifying the Alternatives

These time-savings do not occur at the cost of learning. In a review of findings from 233 studies, Fletcher (2001) found an overall effect size of 0.39 standard deviations for technology-based instruction, and an effect size of 0.84 from 47 studies of interactive multimedia instruction, suggesting overall improvements from 50th percentile to 65th and 80th percentile performance respectively. Thus, while more effective training may be produced as research on technology-based training advances, the current suite of technology-based training tools appears to be adequate for the analyses presented here.

[2] The Military Manpower Training Report (2002) is the last such report issued by the Office of the Under Secretary of Defense for Personnel and Readiness. Change in the average length of specialized skill training since then is assumed to have been small.

Designing the Analysis

Estimates to produce an hour of technology-based instruction range widely depending on content, instructional strategy and personnel costs. One source of estimates is the Joint Knowledge Development and Distribution Capability (JKDDC). As of May 2008, JKDDC had produced over 200 courses with more than 65,000 course completions (Camacho, 2009). In the first quarter of FY 2008 the costs for JKDDC to develop an hour of instruction were about $14,000 and about $4 per hour to deliver it to a student.

We therefore assumed that it would cost about $4.48 million to produce 320 hours of ADL specialized skill training and an additional $183.14 million to deliver it to 143,080 students. The investment for the first year of this training would amount to about $187.62 million.

Establishing Metrics

For this example, the metrics are relatively straightforward and include well-established measures of development and production cost as well as delivery costs. Costs, such as pay and allowances were extracted from Military Composite Standard Pay and Reimbursement Rates (2008).

Table 1. ROI for Technology-Based Specialized Skill Training

Investment		Return	
Develop and produce 320 hours of instruction	320 x $14,000 = $4.48M	Total hours saved by 40% of learners	143,080 x 136 = 19.459M
Deliver 320 hours of instruction to 40% of learners	143,080 x 320 x $4 = $183.14M	Composite pay & reimbursement per hour x hours saved	$42 x 19.459M = $817,273M
Total investment	**$187.62M**	**Total return**	**$817.27M**

Assumes:
- 30% time reduction to train 40% of 357,700 (i.e., 143,080) learners;
- Average course of 456 hours replaced by 320 hours of technology-based training;
- 136 hours saved per learner;
- $14,000/ hour to produce and $4/hour to deliver technology-based training;
- $42 average hourly cost (pay and reimbursement) per learner.

Performing the Analysis

The analysis is summarized in Table 1. It is based on data and values pulled from studies reported in the literature. Factors to consider in calculating the return include:

- Investment costs to develop and produce the 320 hours of technology-based instruction that will replace 456 hours of instruction for 40% of Specialized Skill students;
- Investment costs to deliver these 320 hours to the students;
- The total hours saved by 40% of Specialized Skill students, i.e., 136 hours x 143,080 students;
- The dollar savings in composite pay and reimbursement returned by saving these hours.

Performing a Sensitivity Analysis

Variables to be considered include development and production costs as well as mode-of- training delivery costs. As Table 1 indicates, the ROI is far more sensitive to delivery costs ($183.14M) than to costs to develop and produce the materials ($4.48M). Doubling or tripling the production costs will have relatively little effect on ROI compared to delivery costs. The percent of Specialized Skill students covered by technology-based training would, of course affect the ROI as would the amount of training time saved. The model developed by Angier and Fletcher (1991) covers these issues.

Reporting the Results

The cost model proposes that developing and delivering technology-based instruction to 40% of Specialized Skill students (about 143,080 students) would take 30 percent fewer hours to complete their training: a savings of about 136 hours for each student. Assuming a composite of $42 per hour in pay and allowances (Military Composite Standard Pay, 2008) this use of technology-based instruction would amount to (42 x 143,080 x 136) = $817.27M. Plugging these data and assumptions into an ROI calculation yields:

$$\frac{\$817.27M - \$187.62M}{\$187.62M} = 3.36$$

As summarized in Table 1, the ROI ratio is 3.36, which indicates that $3.36 will be returned for every dollar invested in technology-based specialized skill training under the assumptions of this analysis.

Example 2: Net Present Value and the Rapid Development of Expertise

Savings in time needed to reach training objectives not only reduce training costs, but also increase the supply of people for operational forces without increasing the number of people in uniform – in effect, a force multiplier. How might these savings increase if these students were released into the workforce not only earlier but with knowledge and skills similar to workers with years of experience?

The ROI methodology of Example 1 is insufficiently robust to make this determination. That example assumes a one-time infusion of cash to effect the change to technology-based instruction and to realize the resultant performance improvement. Most training system development investments are not made that way. Instead they involve a series of investments made over a number of years. Moreover, a training system that both compresses the time to train and increases the level of expertise produced will have a more complex impact on both the Schoolhouse and the Fleet. Therefore, it is important to develop a method that can reliably track these multiple investment threads.

For that reason, economists prefer Net Present Value (NPV) to compare investments made over time. NPV is defined as the difference of discounted benefits less discounted costs. It can tell us in today's dollars what the cash value of an investment made over time is likely to be. Differences in NPV for different investments will, as suggested above, not be the final deciding point, other factors can and often will factor in, but knowing these differences will be a significant contribution.

NPV may be calculated as:

$$NPV = \frac{C_1}{(1+i)} + \frac{C_2}{(1+i)^2} + ... + \frac{C_n}{(1+i)^n} = \sum_{t=1}^{n} \frac{C_t}{(1+i)^t}$$

Where C_t is the cash flow in year t and i is the discount, or interest rate. The discount rate is an agreed upon yearly rate, which is intended for use in cost-effectiveness analyses, is established by the United States Office of Management and Budget and published annually in its circular, OMB A-94, Appendix C (2009). An important feature of NPV is that it allows – actually requires – an upfront estimate of the investment time horizon. NPV provides an ideal way to track the effectiveness of investments made during the acquisition lifecycle – including early periods involving research and development.

Example 2 concerns an NPV assessment for training that compresses the time needed to develop expertise. The example involves a DARPA project to develop a Digital Tutor (henceforth called DT) to provide technology-based training for enlisted sailors training to become Navy Information Systems Technicians (ITs).

The DT is intended to capture and model, using advanced artificial intelligence techniques, the best practices of highly skilled tutors delivering adaptable, individualized, one-on-one training. Such instruction has been shown to raise student achievement substantially (Bloom, 1983). But providing one-on-one live instruction using human tutors is cost prohibitive, suggesting that it is both an instructional imperative and an economic impossibility. A solution is provided by computer technology, which can adapt training on a moment-to-moment basis, as tutors must do, making tutorial instruction increasingly affordable and available (Corbett, 2001; Fletcher, 2001).

While the effectiveness of training using tutorial methods has been validated across many studies and assessments (Fletcher 2001), neither the cost implications of severely compressing time to develop expertise, nor the use of tutorial techniques to do so have been demonstrated. A one-on-one tutorial environment that, affordably, both reduces training time while enabling students to perform at the level of experts with years of experience would be a significant boon to training, especially given the continuing working of Moore's Law to decrease the costs and increase the power of basic computer technology (Gorbis & Pescovitz, 2006).

Identifying the Objectives

The primary objective for the DT is to transform sailors with no IT background into experts who are at least equivalent in knowledge and skill to Fleet sailors with seven years of on the job experience, and to do so in a matter of months.

A first step in demonstrating the power of the DT approach was to determine if one-on-one instruction with the very best human tutors could transform novice students into expert ITs. To that end, a 16-week program of instruction was developed. Expert tutors then used it to train a random sample of novice Navy IT students. The knowledge and skills of these students were then compared to those of Fleet ITs who averaged seven years of IT experience. The assessment found that the knowledge and skills of the tutored students equaled and, in many cases, exceeded those of the Fleet ITs. Measures included scores on a 4-hour test of IT knowledge as well as the number of problems solved correctly and the proper application of troubleshooting techniques during about two and a half days spent responding to Fleet-based trouble tickets (Fletcher, 2010).

Identifying the Requirements for Scale

In an average year, the Navy graduates about 2,000 students from IT "A" school. Average class size at any one point can vary, with about 200 students in various stages of course completion being the norm.

Identifying the Alternatives

This NPV analysis contrasts two investment strategies covering an investment time horizon of 12 years. The proposed training system is the IT Digital Tutor which may replace current IT "A" School after four years (although this decision has not yet been made). The alternative approach is to continue IT "A" school training as it is.

Table 2 lays out these two streams of investment. As shown in the table, analysis of the "A" School alternative covers the school annual operating costs plus the cost of an additional seven years experience for "A" School graduates to achieve the competencies and expertise of DT graduates. The DT investment is slightly more complex. First, it covers four years of "A" School operating costs while the DT is under development. During this time "A" School graduates from those four years will still need seven years of Fleet experience – since they are not receiving the benefits of the DT. Accounting for these first four years of "A" School graduates, the number of annual students requiring OJT will taper-off by 2,000 each successive year, so that the Fleet will have to provide this experience for 8,000 graduates in year 5, 6,000 graduates in year 6, and so on until all have had 7 years of OJT at the end of year 11. DT start-up costs will have to be invested in year 5 and DT operating costs will have to be invested in years 5-12.

Table 2 Design for the NPV Analysis

Identifying the Cost Model

Training Option	Year											
	1	2	3	4	5	6	7	8	9	10	11	12
"A" School	A OJT/7	A OJT/7	A OJT/7	A OJT/7	A OJT/7	A OJT/7	A OJT/7	A OJT/7	A OJT/7	A OJT/7	A OJT/7	A OJT/7
"A" School plus Digital Tutor	A OJT/7 DTD	A OJT/7 DTD	A OJT/7 DTD	A OJT/7 DTD	-- OJT/7 DTI DTO	-- OJT/6 DTO	-- OJT/5 DTO	-- OJT/4 DTO	-- OJT/3 DTO	-- OJT/2 DTO	-- OJT/1 DTO	-- -- DTO

A = "A" School Yearly Operating Costs
OJT/n = Yearly On-The-Job Training Costs for n*2000 students
DTD = Yearly DT Development Costs
DTI = DT Start Up and Outfitting Costs
DTO = DT Yearly Operating Costs

Assumptions underlying the NPV analysis for each stream of investment are the following:[3]

- Student costs (e.g., pay, allowances, etc) and schoolhouse infrastructure costs (e.g., electricity, heating, maintenance, etc.) will be the same for both "A" school and DT training.
- Cost per "A" School graduate is $12,876, adjusted to 2009 dollars from NETC Cost Factors Handbook (2003).
- DT graduates will be at the same level of technical expertise as a Fleet IT with 7 years of experience
- A 12 year horizon covers the period of time needed under the DT alternative for all "A" school students to achieve the competencies of DT graduates.
- Figures are in constant 2009 dollars and would have to be inflated for future year defense budgets.
- All "A" school training will be replaced by DT training after year 4. The simplifying, unlikely assumption is that this will happen overnight.
- In both alternatives, 2000 IT students will continue to be enrolled each year.
- Average annual composite/burdened cost per Navy enlisted billet for seven years of service: Yr(1-2) $45,790, Yr(3-4) $51,417, Yr(5-7) $64,246 (Military Composite Standard Pay, 2008).
- Percent of 7-year IT technical capabilities possessed by "A" school graduates: Yr(1) 10%, Yr(2) 20%, Yr(3) 40%, Yr(4) 50%, Yr(5) 65%, Yr(6) 80%; Yr(7) 95% (100% of 7 year IT competencies achieved at the end of year 7).[4]
- Discount rate of 2.4% (extrapolated from US Office of Management and Budget Circular A-94, Appendix C, 2009).
- DT development costs of $50 million and DT start-up costs of $3 million.

Designing the Analysis

Key to the value of the Digital Tutor is the compression of time needed to develop expertise. We assumed that DT graduates will be at the same level of technical expertise as a Fleet IT with seven years of experience. Given the results from testing (Fletcher, 2010), this is a conservative assumption. Both investment alternatives will produce 24,000 students over a 12 year period. Per this assumption, the "A" school alternative will require an additional seven years of Fleet on job training (OJT) to achieve the same level of technical competence as a DT graduate. The cost of this experience for each "A" school graduate is expressed by the following formula:

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3 These assumptions are made for this example and do not imply any commitment by the Navy or other parties.

4 Based on SME survey of IT Chiefs.

$$Cost\_OJT = \sum_{t=1}^{n} (O_t \bullet P_t)$$

Where O is the proportion of time that must be spent in OJT with composite pay and allowances, P, for the sailor during year t. With this formula and our assumptions, the per student cost (in constant, not discounted dollars) for seven years of this OJT experience per "A" school graduate will be:

Yr(1) (0.90 x $45,790) + Yr(2) (0.80 x $45,790) +
Yr(3) (0.60 x $51,417) + Yr(4) (0.50 x $51,417) +
Yr(5) (0.35 x $64,246) + Yr(6) (0.20 x $64,246) +
Yr(7) (0.05 x $64,246) = $169,737.

Establishing Metrics

The metrics are based on outcomes from the DT assessment described by Fletcher (2010). Its results allowed us to equate skill levels across the DT IT students and the Fleet ITs for the NPV analysis.

Performing the Analysis

The NPV analysis comparing "A" School with DT IT training is summarized in Table 3. The discount rate of 2.4 percent was applied to yearly costs to calculate NPV in accord with the formula shown earlier. Both alternatives in Table 3 assume that 24,000 IT graduates will be produced over the 12 years covered by the analysis. Under the continuing "A" school alternative, all 24,000 graduates will be produced using current technologies and approaches. Under our assumptions, they will need an additional seven years to reach the technical abilities of DT graduates. The total costs for producing 24,000 graduates by continuing current "A" school practices followed by seven years of OJT will be $4,459.8 million in today's dollars.

Current Training Costs: NPV for "A" School Continuation		Proposed Training Costs: NPV for Digital Tutor Introduction	
Per graduate cost for "A" school student	12,876	Per graduate cost for "A" school student	12,876
Total cost for 24,000 "A" school graduates (Yrs 1-12)	309,024,000	Total cost to produce 8,000 "A" school graduates ITs (Yrs 1-4)	103,008,000
Per student cost for 7 yrs of OJT experience after "A" school	172,949	Per student cost for 7 yrs of OJT experience after "A" school	172,949
Total OJT cost for 24,000 "A" school graduates	4,150,783,200	Total OJT cost for 8,000 "A" school graduates	1,383,594,400
		R&D & start up costs for DT	53,000,000
		Total cost to produce 16,000 DT graduate ITs	206,016,000
Total Non-Discounted Costs	$4,459,807,200	Total Non-Discounted Costs	$1,692,618,400
NPV over 12 years	$3,835,490,179	NPV over 12 years	$2,515,704,812
NPV Difference: $3,835M - $2,516M = $1,319M			

Table 3. NPV Analysis: "A" School Continuation Versus DT Development and Implementation

Under the DT alternative, 8,000 "A" school graduates will be produced (years 1-4) using current technologies and approaches while the DT continues its development. In the eight years after that (years 5-12), 16,000 students will graduate from the DT program. The "A" school graduates, from years 1-4, will require the additional seven years of OJT to match the DT graduates in technical ability. The costs for these "A" school students along with the costs for developing, implementing, and operating the DT alternative with its 16,000 graduates will total $1,692.6 million in today's dollars.

The NPV difference between continuing "A" school technologies and practices and developing and implementing the DT is $1,319 million in properly discounted dollars over a 12-year period. An analysis of this sort cannot escape controversy, but whatever the agreed NPV difference may be, it seems likely to favor the DT alternative by a substantial amount.

Performing a Sensitivity Analysis

The calculated cost hinges on the IT Chiefs' judgment of recent "A" school graduates competencies relative to those of Fleet ITs with seven years of experience. Other assumptions could be entered into this calculation. The composite pay and allowance costs are based on an assumption of a rise in rank from E-2 to E-5, and could be adjusted if needed. Costs for supervisory and mentoring time are not included, nor are the opportunity costs of assigning experienced ITs to supervisory duties in place of their regular IT tasks. We did not have the means to collect reliable data on this issue, but expanding the OJT cost formula would allow its inclusion.

We assumed that all costs would be incurred at the end of each period, i.e., each year. This approach is characteristic of NPV as opposed to PV (present value) analyses. Given the emphasis today on developing training technologies that target reductions in schoolhouse costs, one might expect the largest savings to come from making residential, schoolhouse training cheaper. As Table 3 suggests, the cost effectiveness of removing the need for OJT far outweighs the cost effectiveness of reducing schoolhouse costs and sending less-qualified sailors out for further training in the Fleet.

Reporting the Results

As Table 3 indicates, significant cost savings are clearly available from a training system that compresses the time needed to develop expertise – over $1B across the 12 year horizon used in this example. Considered in terms of the dozens of ratings, and tens of thousands of sailors, to which this technology could be applied (assuming similar initial investment costs), the overall savings are significant. These findings suggest in turn that compressing the time to develop expertise is, to adapt Drucker's terms (1993), not just a matter of doing training right, but doing the right training. The NPV assessment also addresses Kirkpatrick's (1987) evaluation Levels 3 and 4, which go beyond interviews (Level 1) and achieving training objectives (Level 2), to demonstrate both an impact on job performance (Level 3) and on operational effectiveness (Level 4). These last two levels target the most basic reason for doing training and most directly answer Admiral Kidd's question. They are also difficult to perform and rarely addressed by the training community.

CONCLUSION

Training has long been used to reduce the time that experience needs to produce human competence. Technology-based training, if designed properly and used effectively, appears capable of reducing this time well beyond that of more traditional training while producing levels of competence that extend into the realm of genuine expertise. Standard ROI involving a single infusion of funds, as illustrated in Example 1, appears to be a reasonable and straightforward way to assess return from more rapid development of technical competence.

The value of compressing the time necessary to produce levels of expertise, may be further assessed by comparisons with the costs of providing the necessary levels of expertise through years of OJT. Economic theory and practice recommend NPV for estimating return on investments made over time – especially when the amount invested differs from period to period. Decision makers may be further aided by the ability to compare investment alternatives in present day monetary units (e.g., dollars). Example 2 illustrates the value of a time-series of investments used to achieve expertise rapidly. Results from both examples and the frameworks they suggest should better inform decisions concerning investments in different approaches to training and in training itself as a viable alternative and contributor to force operational effectiveness.

Despite the considerable savings the examples suggest, at least one major problem must be dealt with before they and similar analyses can lead to actionable decision-making. Local training commands would have to make the necessary investments but would receive few, if any, of the returns. The problem appears to be the perennial one of increasing up-front capital investments to save later life-cycle costs. Example 2 suggests that the practice of passing training requirements from the school-house to the operating force is extremely expensive and potentially detrimental to operational effectiveness. If our forces are to benefit from the training approaches examined here, the training community must be given adequate capital resources to take advantage of them. Our analyses suggest the significant value of doing so.

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