DERIVING THEORETICALLY-BASED PRINCIPLES OF TRAINING EFFECTIVENESS TO OPTIMIZE TRAINING SYSTEM DESIGN

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ABSTRACT

Recent advances in technology and rapid changes in the world have placed increasingly stringent demands on the human operator in many military systems. The need for improved and more varied skill levels, coupled with current fiscal constraints, requires that modern military training systems must impart the complicated, higher-order skills required to operate modern combat systems in less time and with a lower dollar investment than in recent history. Therefore, the modern training challenge demands an optimization of training resources--a return on investment that results in an uncompromisingly high level of readiness at the lowest possible cost and in the shortest time. The purpose of the present research was to advance understanding of effective training system design by investigating factors that may affect significantly the success of training in terms of performance improvement in the operational environment. The benefit of such work is that it can lead to generalizable training design guidelines that will increase the probability of effective training with a relatively small investment. In order to accomplish this goal, a comprehensive model of training effectiveness was first developed and used as a basis to specify testable hypotheses. A large-scale data collection effort was then conducted with Navy recruits. Results indicated that several "non-technical" factors had a significant impact on training outcomes in this setting. These factors included: self-confidence, task-related attitudes, expectations for training, training fulfillment, and pre-training motivation. These results are discussed in terms of their implications for improving training system design.

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INTRODUCTION

There is little doubt that Fleet readiness, safety and performance depend largely on the extent to which training systems impart crucial knowledge and skills. Current fiscal constraints demand further that military training resources are optimized--that is, that they accomplish required training objectives at the lowest cost and in the shortest amount of time. It is generally agreed, therefore, that attention must be directed toward understanding the factors that foster and inhibit training effectiveness and transfer of training so that the highest payoff in terms of performance improvement is achieved.

Past research into training system design has most often concentrated on a relatively small set of variables such as training method, content, media and equipment. While this research is important--training variables are a critical part of the effectiveness equation--training effectiveness is a complex phenomenon. There are numerous factors which can have an influence on training effectiveness, independent of training quality. As Goldstein noted, "we must consider training as a system within work organizations rather than simply treating instruction as a separate technology" (1980, p. 263). We need to better understand the many factors that may contribute to, or detract from, training effectiveness. In particular, there is a need to examine a variety of often overlooked variables in the training equation including trainee attitudes, expectations, and motivations (Noe, 1986), and organizational/situational factors, e.g., supervisor support in the transfer environment (Noe & Schmitt, 1986). In addition, general theories of training effectiveness are needed to guide the generation of hypotheses about training system design, and to provide a basis upon which to make design decisions (Cannon-Bowers, Tannenbaum, Salas, & Converse, 1991).

The consequences of failing to specify and consider all potentially important factors in training system design (and perhaps more importantly, the relationship among factors) are both practical and theoretical. From a theoretical standpoint, the lack of comprehensive theories of training effectiveness makes it difficult to determine why training may or may not have been successful, or how it might generalize to other environments (Cannon-Bowers et al. 1991). Related to this, it is difficult to generate general principles of training system design since it is unclear why, or by what mechanisms, training is successful or unsuccessful. On a more practical level, there may be a sub-optimization of training resource allocation and expenditure,

and of training effectiveness since design decisions are not based on sound principles of training. For example, a training program that fails due to low motivation on the part of trainees may lead a designer to conclude erroneously that the failure was due to the training methods that were employed.

Recently, several researchers in the training area have contented that a host of factors not typically considered in training design research may have a significant impact on training effectiveness (Noe & Schmitt, 1986; Noe, 1986; Tannenbaum, Mathieu, Salas & Cannon-Bowers, 1991). In general, these factors can be characterized as those that a trainee brings to the training situation, those related to the training system itself, and those stemming from the organizational or operational context in which the training occurs. Research in this area has suggested that factors such as job involvement, performance expectations, training fulfillment, career planning and organizational favorability can all have an impact on training effectiveness (Mathieu, Tannenbaum, & Salas, in press; Noe & Schmitt, 1986; Tannenbaum et al., 1991).

Another area of interest to the current research relates to the need to define the concept of "training effectiveness" itself. Specifically, it has been typical in past work to treat training effectiveness as a relatively simple, uni-dimensional construct. A notable exception here is the theorizing of Kirkpatrick (1976), where he decomposed the concept of training effectiveness into several separate outcomes: reactions, learning, behavior and organizational results. According to Kirkpatrick, training can have an impact on any (or all) of these outcomes. With respect to the current research, it is our contention that specifying and assessing various components of training effectiveness is crucial to a full understanding of how and why training is successful. Moreover, it is reasonable to hypothesize that particular training system features will have a differential impact on various outcomes. For example, trainees may respond favorably to a training program (reactions) without actually learning targeted material, or they may learn targeted concepts but be unable to apply these to the job.

The purpose of the current research was to extend past work in the training effectiveness area by specifying a comprehensive model of training effectiveness, and studying directly the impact of selected individual and situational factors on various training effectiveness components in a Navy training environment. Of particular interest was the study of "trainability" factors; that is, factors that a trainee brings to the training program which affect his/her ability to acquire and apply targeted skills, and how these affect important training outcomes.

OBJECTIVES

The objectives of the current research were to: 1) develop a comprehensive model of training effectiveness that would provide a framework in which to investigate the impact of training effectiveness factors, 2) determine empirically how, and to what extent, selected training effectiveness factors affect training outcomes in a military training environment, and 3) to begin to derive recommendations for incorporating knowledge about training effectiveness factors into the design of training systems as a means to enhance training effectiveness.

APPROACH

A series of research questions was first generated to guide subsequent research and model development. These included:
1) Which organizational and trainability factors are likely to affect training effectiveness?
2) What are the important components or categories of training effectiveness?
3) What is the relationship among factors that affect training effectiveness?
4) How can these factors be reliably measured?
5) What is the impact of organizational and trainability factors in an actual training environment?
6) How might data regarding the impact of these factors on training effectiveness be used to improve the design of training systems?

To begin to answer these questions, a review and synthesis of the training literature was conducted in order to generate a comprehensive model of training effectiveness. The purpose of this model was to delineate the

most important organizational and trainability factors that are hypothesized to affect training outcomes (question 1 above), to delineate the various facets of training effectiveness (question 2 above), and to describe how these variables might be related to one another and to training effectiveness (question 3 above).

Model Characteristics

Inspection of Figure 1 reveals that the model of training effectiveness adopts a longitudinal, systems oriented perspective that considers events that occur before, during, and after training. It focuses specifically on characteristics of the organization and work environment, and characteristics of the individual trainee as crucial "input" factors.

With respect to organizational factors, past work has shown that these can have an impact both before and after training. Prior to training, organizational and situational factors should have a direct influence on training expectations and desires and on training motivation, and subsequently will have an indirect effect on training effectiveness. Organizational culture, history, and policies can shape trainees' expectations about training. For example, Eddy, Glad, and Wilkins (1967) found that students from supportive, cohesive agencies expressed higher degrees of interest in course structure and traditional academic approaches to knowledge than those from less cohesive and supportive agencies.

After training, organizational and situational variables are hypothesized to influence trainees' motivation to transfer what they learned and their subsequent job performance. Factors such as transfer climate and supervisor support are hypothesized to affect motivation, while issues such as resource availability are hypothesized to influence job performance directly. Baumgartel and Jeanpierre (1972) and Baumgartel, Reynolds, and Pathan (1984) found in this regard that employee perceptions of transfer climate was related to effort to apply training.

The model of training effectiveness shown in Figure 1 also included several individual factors. These include cognitive ability, self-efficacy and organizational commitment, expectations and pre-training motivation. Research into several of these variables will be briefly summarized below.

To begin with, many studies have examined the effects of cognitive ability in training environments. For example, Neel and Dunn (1960) found a relationship between intelligence test scores and course exam scores. Tubiana and Ben-Shakar (1982) noted the connection between an intelligence test and officers' ratings of potential at the conclusion of training. Mobley, Hand, Baker, and Meglino (1979) found a significant difference between recruit training graduates and those that failed to complete training on the AFQT (a form of scoring the Armed Service Vocational Aptitude Battery--ASVAB). Fox et al. (1969) and McFann (1969) also reported a relationship between the AFQT and training effectiveness as measured by training time and passing training, respectively.

In general, the research suggests that trainees with greater ability will demonstrate better training performance and higher scores on learning measures. This has important implications for selecting employees for training, particularly if training is costly and failure is possible. However, these studies do not allow us to conclude that higher ability people learn more in training. Most of the studies that addressed "learning" assessed academic performance (post-training scores) and not learning per se. That is, the studies demonstrate that trainees who possess greater ability do better on performance and/or learning tests after training, although the studies do not indicate whether high ability individuals gained more from training than did low ability individuals. Learning implies a change or an improvement in knowledge as a result of training. It is likely that the higher ability people would have scored better on the knowledge tests even without training.

It is logical that ability sets a limit on learning. If training is at a level beyond a person's ability then no learning can occur. Perhaps it is best to think of ability as resource capacity. If sufficient resources exist then learning can occur and other factors (e.g., motivation, competing tasks) will also influence the degree of learning. Kanfer and Ackerman (1989)

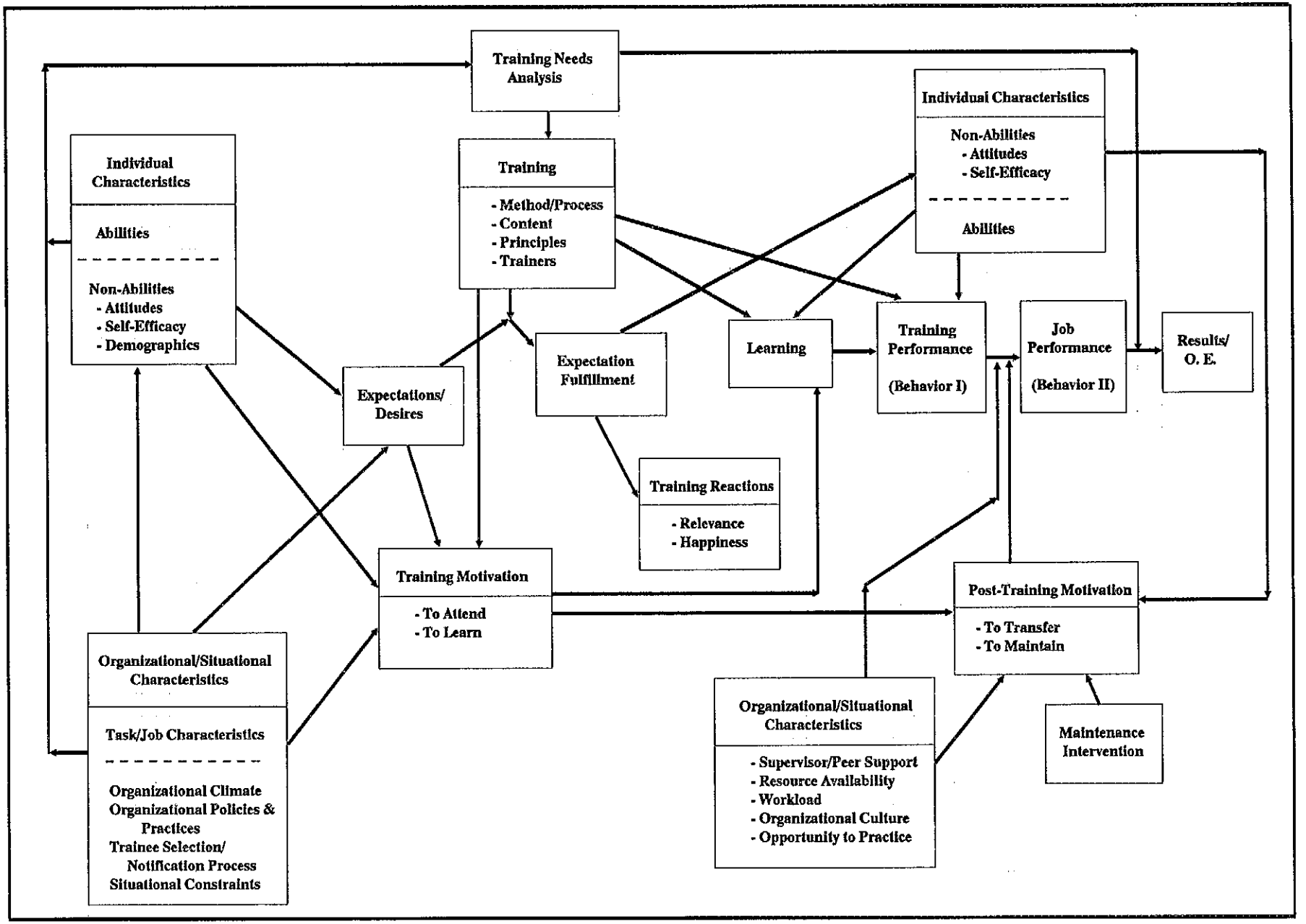

Figure 1: Model of Training Effectiveness

expanded on the work of Kahneman (1973) and proposed a model of ability-motivation interactions. They suggest that individuals have a particular resource capacity level and motivational processes will influence personal allocation of those resources. The greater the attentional demands of the task the greater the importance of cognitive ability. Future research needs to assess the relative affects of cognitive ability on motivation and training success.

Self-efficacy, which can be defined as self perceived competence on the task, is also be considered an important training variable in the model. Self-efficacy has been shown to be related to subsequent task performance in numerous studies (Barling & Beattie, 1983; Locke, Frederick, Lee, & Bobko, 1984; Taylor, Locke, Lee, & Gist, 1984). In the present context, pre-training self-efficacy may be an important predictor of learning and training performance. Recently, Gist, Schwoerer, and Rosen (1989) demonstrated a connection between pre-training self-efficacy and subsequent training performance in computer software training. Eden and Ravid (1982) manipulated trainees' expectations of their performance by having a psychologist tell some military trainees that they have high success potential. They found self-expectations of performance were related to subsequent trainee performance.

Trainees' work related attitudes can clearly affect their receptiveness to training. In particular, their level of commitment to the organization is likely to predispose them to view training as more or less useful, both to themselves and to the organization. Organizational commitment is defined as "...the relative strength of an individual's identification with and involvement in a particular organization. Conceptually, it can be characterized by at least three factors: 1) a strong belief in and acceptance of the organization's goals and values; 2) a willingness to exert considerable effort on behalf of the organization; and 3) a strong desire to maintain membership in the organization" (Mowday, Porter, & Steers, 1982; p. 27).

It follows that current employees who are more committed to the organization would be more likely to: 1) perceive that training would be beneficial; 2) be willing to exert a great deal of effort in order to be successful in training; and 3) want to do well in training in order to solidify their position in the organization. For example, Mobley, Hand, Baker, and Meglino, (1979) found intention to remain with the military to be related to completion of recruit training. Noe and Schmitt (1986) found job involvement was related to learning but not to behavior change or motivation to transfer. Additional research is needed which examines the influence of trainees'attitudes on training effectiveness.

Another variable of interest is training motivation. Conceptually, expectancy theory provides a useful framework for examining training motivation (see Lawler, 1973 and Vroom, 1964, for detail on expectancy theory). In the training context, expectancy theory would suggest that trainees consider the utility of the training in attaining desired outcomes. Trainees consider this in deciding whether to attend training, to expend effort to learn, and to persist in attempting to apply what they have learned.

Despite the centrality of motivation to most conceptions of performance there has not been a great deal of research that has examined the role of trainee motivation in training effectiveness. Hicks (1984) reported a significant correlation between motivation to learn and self-reported learning. Mobley et al. (1979) found an expectancy based motivation measure to be related to training completion. Biersner, Ryman, and Rahe (1977) also found trainee motivation predictive of the completion of diver training.

In contrast, Noe and Schmitt (1986) found no relationship between pre-training motivation to learn and post-training learning, behavior change, or motivation to transfer. Unfortunately, a small sample size and some psychometric problems required them to collapse motivation, expectation, and situational variables together. Their resulting motivation measures are difficult to interpret. The lack of research on training motivation is a critical gap in improving our understanding of training effectiveness. Future research should address

the measurement issues associated with training motivation including a consideration of longitudinal data collection.

To summarize,, the model of training effectiveness hypothesizes that organizational and individual factors will combine to affect a trainee's expectations for training, and in turn, his/her pre-training motivation. Moving to the right of the model (see Figure 1), it is hypothesized that characteristics of the training program itself combine with input factors to affect various training outcomes. Important training program characteristics include: method, content, equipment, devices, instructional strategies, and the like.

Finally, the model of training effectiveness developed in the current research reconsiders and extends Kirkpatrick's (1976) hierarchy of training evaluation. As noted, Kirkpatrick hypothesized that training can lead to several separate, but related training outcomes. The present model builds on this work by considering behavior change at two levels: performance in training and performance on the job. The rational here is that a trainee may be able to demonstrate critical skills at the conclusion of training, but be unable to apply these on the job for a variety of reasons (for example, unfavorable organizational conditions, differences between the training and operational environment, and the like). In fact, transfer of training has been hypothesized to be a function of several factors (see Baldwin & Ford, 1988) that would mitigate against successful application of training to the job. This has obvious implications for training effectiveness research, since the training program itself could be sound, but considered unsuccessful because trainees are unable to apply the skills they have learned due to external factors.

The model also departs from Kirkpatrick's original conceptualization by removing the causal link between trainee reactions and learning. Specifically, we hypothesize that trainee reactions on the one hand, and learning, performance and results on the other, are affected by different training program components and input factors. Reactions are affected by pre-training motivation, and also by the extent to which the training fulfills the trainee's expectations for training (called training fulfillment in the model). The implication of this contention is that assessing trainee reactions to training (which is a common practice) will not indicate the extent to which trainees have learned targeted material, or can/will apply these to the job.

METHODS

Once the model of training effectiveness was specified, it was used to generate hypotheses regarding the impact of trainability factors on selected training outcomes. Two topics were considered initially: 1) can trainability factors be measured reliably, and 2) what impact do *trainability factors have on actual training* performance in a military environment. These questions were addressed in a longitudinal investigation with Navy recruits at Recruit Training Command, Orlando, FL. This site was selected for initial work because it provided a large subject pool that was required for measurement scale construction.

Measurement scales were designed to measure selected training effectiveness factors based on past work. The research design (shown in Table 1) involved first assessing the trainees' trainability immediately upon their arrival at Recruit Training Command. During training, selected outcome measures were then recorded (see Table 1), and measurement scales were readministered at the conclusion of training. A total of 1037 trainees participated in the research. Their average age was 19.98 (SD = 2.66). Of the 1037 trainees, data were available from 666 at all three data collection points. Average age of the final sample (n = 666) was 19.84 (SD = 2.43). The final sample consisted of 368 men and 298 women.

ANALYSIS & RESULTS

The psychometric properties of scales designed to measure various training effectiveness factors were investigated by calculating internal consistency coefficients (Cronbach's alphas) on all scales. Results indicated that reliability ranged from .82 to .96 for pre-training scales; from .87 to .95 for post-training measures; and from .69 to .91 for effectiveness (outcome) measures. In addition, a factor analysis of the scales indicated that all had simple, single

TABLE 1.
Research Design: Variables and Time of Measurement

Time of Measurement		
Pre-Training	During Training	Post-Training
Cognitive Ability	Academic Tests	Attitudes
Attitudes	Honors	Self-Efficacy
Self-Efficacy	Demerits	Perceptions of Training
Performance Expectations	Inspection Scores	Motivation
Training Expectations		Reactions
Pre-Training Motivation		Self-Rated Performance
		Training Fulfillment

factor structures. Taken together, these results suggested that measurement scales were adequate to support hypothesis testing.

A series of hierarchical multiple regressions was then performed on the data to determine the causal relationship among training effectiveness factors, and between training effectiveness factors and training outcomes. Referring back to the model of training effectiveness (see Figure 1), it can be hypothesized first that trainability factors have a direct effect on expectations for training and performance. Table 2 presents results pertinent to this hypothesis. For each dependent variable (listed across the top), Table 2 shows significant antecedent causal factors (i.e., variables that remained significant in the regression equation), along with the variance accounted for (R^2), F-test, degrees of freedom (df) for the test and level of probability (p). Inspection of Table 2 reveals that academic self-efficacy, physical self-efficacy and commitment to the Navy all significantly predicted expectations for performance, while physical self-efficacy, commitment to the Navy, and cognitive ability were significant predictors of training expectations.

Next, it was hypothesized that pre-training factors would have a significant impact on training outcomes. Table 3 displays the results of regression analyses applied to test these hypotheses. As can be seen from this table, a number of trainability factors had a significant affect of reactions and performance measures. These included: pre-training motivation, physical self-efficacy, age, gender, cognitive ability, and expectations, with several appearing in more than one analysis.

In addition to regression analyses, a discriminant function analysis was computed to determine whether it was possible to predict which trainees would complete training based on their initial responses to trainability items. Statistically, discriminant function analysis seeks to find the best linear combination of predictor scores that can most effectively predict group membership. In the present analysis, four variables appeared to be significant predictors of attrition: expectation ($p < .05$), self-efficacy ($p < .01$), commitment to the Navy ($p < .01$) and pre-training motivation ($p < .02$). A Chi Square coefficient of 12.07 ($df = 4, 340$, $p < .02$) indicated that the amount of variance predicted in attrition scores (16%) was statistically significant. Finally, it was found that training fulfillment

TABLE 2.
Regression Analysis of Significant Predictors of
Expectations for Training and Performance

	Dependent Variable	
	Performance Expectations	Training Expectations
Variations in the Equation	-Academic Self-Efficacy -Physical Self-Efficacy -Commitment	-Physical Self-Efficacy -Commitment -Cognitive Ability
R^2	.39	.24
F	53.30	25.85
df	(8, 640)	(8, 640)
p	< .01	< .01

TABLE 3.
Regression Analysis of Significant Predictors
of Training Outcomes

	Dependent Variable		
	Reactions to Training	Academic Test Scores	Demerits/ Inspection
Variables in the Equation	-Pre-Training Motivation -Physical Self-Efficacy -Age	-Pre-Training Motivation -Physical Self-Efficacy -Age -Gender -Cognitive Ability	-Expectations -Cognitive Ability
R^2 for Equation	.35	.48	.04
F for Equation	146.39	61.28	3.89
df	(10, 634)	(10, 634)	(10, 634)
p	< .01	< .01	< .01

(defined as the extent to which training met trainees' expectations and was consistent with their desires for training) was significantly related to post-training attitudes and motivation.

DISCUSSION

It can be concluded from this research that several trainability variables have a significant impact on training outcomes (reactions and performance) in the sample tested. These include: expectations, self-efficacy, motivation, cognitive ability and commitment to the Navy. Further, this research supports the conclusion that trainability factors are related to completion of training. Finally, the finding that training fulfillment was related to post-training variables is important because it suggests that factors in the training program may affect the likelihood that a trainee will apply the skills learned in training to the job performance situation. Taken together, these results suggest that no matter how well a training system is designed, it may not be maximally effective due to incompatibility with trainee attitudes or expectations, or low trainee motivation.

The benefits of this research are twofold. First, it provides a theoretical basis for training *design and measurement by specifying that* factors predicted to affect training success. Such work is crucial to the advancement of the training field, as well as for specifying principles of training that can generalize across settings. From this perspective, the current work has contributed by specifying a comprehensive model of training effectiveness that identifies and links factors hypothesized to be related to training outcomes. Further work is needed to test more fully the relationships laid out in the model.
A second benefit of the present research is to provide a basis for generating principles of training system design that will maximize the chances that training will be successful. From the current findings, the following initial principles can be offered in this regard:

1) The level of self-efficacy of trainees should be assessed prior to training.
2) Remedial training to raise self-efficacy levels prior to training will enhance the needed of positive training outcomes.
3) Trainees should be led to have realistic expectations for training.
4) Interventions designed to increase trainee commitment to the organization will enhance the likelihood of successful training.
5) Efforts to improve trainee motivation prior to training can lead to better training outcomes.

Further research is needed to validate these propositions in other training settings. In addition, future research that tests other relationships in the model of training effectiveness would advance understanding of how training systems can be designed to ensure optimal results.

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