TOWARD GUIDANCE IN THE DEVELOPMENT OF SHIPBOARD TRAINING SYSTEMS

Katrina E. Ricci, Janis A. Cannon-Bowers, Eduardo Salas
Naval Air Warfare Center Training Systems Division, Orlando, FL
and
Steve W. J. Kozlowski
Michigan State University, East Lansing, MI

ABSTRACT

Due to funding constraints, there is an ever increasing demand to satisfy training needs as efficiently as possible, yet maintain high levels of combat readiness. To do so, tradeoffs are necessary, and, more and more, training must be accomplished on an “as-needed” basis. That is, it is necessary to rely less on formal school-house training (which has high overhead costs), and more on deployable training systems. Fortunately, opportunities exist to exploit advanced technologies and their associated cost savings through the design of shipboard training. This is particularly true when considering the training capability likely to be present in the next generation of Navy surface vessels (i.e., LPD-17, CV(X), and DD-21). Specifically, two training capabilities are likely to be prominent: 1) the capability to selectively generate a variety of simulated practice scenarios, and 2) the capability to monitor trainee performance in real-time and to generate extensive, detail, and specific information about the trainee’s performance. Thus, it is assumed that precise control of *practice* and *feedback* will be key attributes of advance shipboard training systems. However, little attention has been paid the theoretical foundation that best serves the ability to train afloat. Therefore, theoretically based principles of instruction must be addressed to guide the development of shipboard training. This paper is particularly focused on the use of embeddded/scenario-based training (a feature likely to be most valuable in future shipboard training) and the use of various provisions of feedback.

The objective of this paper is to discuss a theoretical approach for future shipboard scenario-based training and to begin to provide guidance for such training. This effort will address the design of onboard training by providing a theoretical foundation on which to base shipboard training that includes the trainee, the skills and knowledge to be trained, and the methods of training implementation. Further, two experiments highlighting a portion of this model will be presented. The value of this effort lies in its ability to reduce costs associated with traditional school-house training by identifying opportunities for efficient and effective shipboard training and remediation.

AUTHORS

Katrina E. Ricci is a Research Psychologist with NAWCTSD, Orlando, FL. She received her M.S. in Industrial/Organizational Psychology from the University of Central Florida in 1989. Her research interests include skill acquisition, instructional strategies, performance measurement, and training effectiveness evaluation.

Janis Cannon-Bowers, Ph. D. is a Senior Research Psychologist at NAWCTSD where she has worked for over ten years. She has a M.A. and Ph.D. from the University of South Florida in Industrial/Organizational Psychology. Her current research interests are in team training and performance, training effectiveness ad the application of advanced technology to the design of embedded training systems.

Eduardo Salas, Ph. D. is a senior research psychologist and head of the Training Technology Development Branch of the Naval Air Warfare Center Training Systems Division. He received his Ph.D.

degree (1984) in industrial and organizational psychology from Old Dominion University. Dr. Salas has co-authored over 75 journal articles and book chapters and has coedited five books. He is on the editorial boards of Human Factors, Personnel Psychology, Military Psychology, Interamerican Journal of Psychology, and Training Research Journal. His research interests include team training and performance, training effectiveness, tactical decision making under stress, team decision making, performance measurement, and learning strategies for teams.

Steve W. J. Kozlowski, Ph. D. is a Professor of Psychology at Michigan State University, East Lansing, MI. Dr. Kozlowski received his Ph. D. in Industrial and Organizational Psychology from the Pennsylvania State University in 1982. His research interests include organizational behavior, learning, adaptation, instructional interventions, and judgment and rating behavior.

TOWARD GUIDANCE IN THE DEVELOPMENT OF SHIPBOARD TRAINING SYSTEMS

Katrina E. Ricci, Janis A. Cannon-Bowers, Eduardo Salas
Naval Air Warfare Center Training Systems Division, Orlando, FL
and
Steve W. J. Kozlowski
Michigan State University, East Lansing, MI

INTRODUCTION

Modern combat readiness requires personnel to adapt to rapidly changing scenarios under time compressed conditions. The warfighting readiness of our forces depends on the ability to quickly react to new "hot spots". This means that training must foster skills and knowledge that are resilient to decay and adaptable to changing contexts. Therefore, training mechanisms must be in place to provide deployable remediation or initial training as circumstances arise. Fortunately, advances in training technology are furthering the ability to train anytime, anywhere. Systems such as embedded training, distributed interactive simulation, intelligent computer-assisted instruction, and multi-media instructional systems provide vehicles for which such training can occur. These systems allow for training enhancement and remediation of skills and knowledge as well as the opportunity to engage in mission rehearsal exercises that can maximize combat readiness.

It is impossible to predict with certainty the specific training capabilities that will be possible to embed in the next generation of advanced systems. However, two training capabilities are likely to be prominent in whatever form the technology assumes: 1) the capability to selectively generate a variety of simulated practice scenarios, and 2) the capability to monitor trainee performance in real-time and to generate extensive, detailed, and specific information about the trainee's performance. Thus, it is assumed that precise control of practice and feedback will be key attributes of advanced systems. The theoretical and research challenge is to determine the best ways to leverage the instructional potential of these training capabilities.

Although the requirement exists and training technologies are available to provide shipboard training, there remains a need for a theoretically-driven approach to designing shipboard training. This problem becomes highly evident with the design of new ships for the next century (i.e., LPD-17, CVX, and DD-21). The ship of the future is intended to provide state-of-the art shipboard training. The danger here is in assuming that advanced technology will automatically result in advanced learning. If we are to optimize the value of advanced training technologies, research on the cognitive processes that promote learning must occur in parallel. For some time now, the training community has acknowledged the concept of just-in-time training, as well as other current training trends such as on-demand training, discovery learning and mission rehearsal. However, no attempt has been made to clearly articulate the issues that surround and impact their success. Research is necessary in order to maximize the effectiveness of this onboard training. The purpose of this effort is to take a principled approach in investigating these issues and begin to produce guidelines for their application.

THEORETICAL MODEL AND APPROACH

A theoretically based model of training applicable to a shipboard setting is presented in Figure 1. This model integrates: relevant trainee individual differences; key training components that combine into a training strategy; and the self-regulatory behaviors, cognitions, and affect that contribute to both proximal (i.e., *learning*) and distal (i.e.,

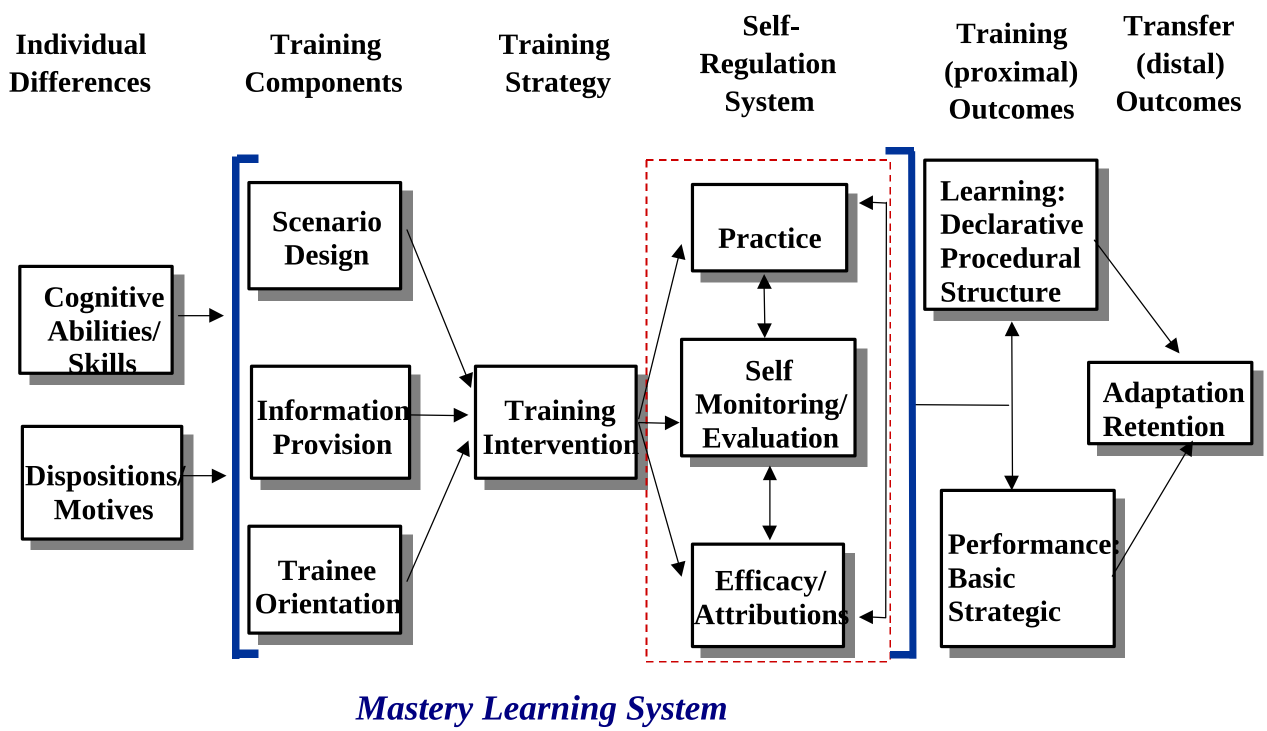

Figure 1: A Theoretical Model of Shipboard Training

adaptability) training outcomes. Recent research on learning, cognition, training design, and complex skill acquisition provides the theoretical mechanisms for this approach.

The core of the conceptual model is the Mastery Learning System (MLS). The MLS approach is designed to enhance the development of complex knowledge, learning strategies, and adaptive capabilities that are grounded in the performance context. MLS is based on a self-regulatory model of learning, motivation, and performance (Ames & Archer, 1988; Bandura, 1991; Karoly, 1993; Latham & Locke, 1991; Smith, Ford, & Kozlowski, 1997). Self-regulatory models have been shown to be particularly effective at enhancing learning for difficult and complex tasks. At its most elemental level, self-regulation involves monitoring the differences between goals and current states. Negative discrepancies induce self-evaluation and, depending on affective reactions and causal attributions, reallocation of attention and effort to move closer toward goal accomplishment.

A paradox exists within training that may moderate the ability to determine effective training strategies. That is, performance following skill acquisition is often a poor predictor of transfer or retention performance. For example, specific training strategies as well as the scheduling of performance feedback may deter skill acquisition, yet foster retention and transfer (Schmidt & Bjork, 1992). Given this problem, research is necessary to determine which additional factors serve to moderate the potential effectiveness of shipboard training.

INFORMATION PROVISION

Of particular interest for the research presented here is the impact of information provision, or feedback, on the learning process. This research focus on information provision addresses how the instructional effects of feedback can be enhanced when properly used in combination with other training components.

Experiment 1: Descriptive Feedback

Principles of training design generally assume that descriptive feedback should be specific, accurate, frequent, consistent, and process oriented. The next generation of advanced systems will be able to deliver descriptive feedback with these properties in prodigious amounts. The questions are: what information, how much of it, and in what sequence? For example, too much descriptive feedback may limit attentional resources needed for learning, diverting it to less important aspects of performance, and may overwhelm the trainee with a mass of raw information. In contrast, more limited descriptive feedback that is targeted and sequenced to match current levels of skill development may better focus trainee attention on more proximal and attainable learning goals, thereby enhancing self-regulation that leads to skill acquisition. Moreover, feedback is likely to be most useful when coupled with appropriate instructional objectives. Thus, this effect is likely to be enhanced when sequenced feedback is consistent with mastery versus performance instructional goals; that is, goals that emphasize *learning objectives* (i.e., processes) vs. goals that emphasize achieving specific *performance* levels (i.e., outcomes). Many training environments emphasize performance objectives, which can inadvertently interfere with the learning of complex skills.

Research Propositions. It was hypothesized that mastery training goals would yield superior adaptive transfer performance, yet yield less effective performance at the end of training relative to performance training goals. Further, it was hypothesized that feedback consistent with the type of training goal will enhance learning, training performance, and adaptive performance. Specifically: 1) Sequenced *mastery* feedback will boost learning and transfer when coupled with mastery goals. The effects of coupling with performance goals are unclear. Sequenced mastery feedback may shift attention away from performance goals toward mastery goals, enhancing learning, or they may interfere with learning thereby adversely affecting training performance and transfer. 2) Sequenced *performance* feedback will boost training performance when coupled with performance goals. Such feedback is generally expected to be less effective for trainees given mastery goals, although prior research indicates that mastery goals coupled with performance feedback is an effective training strategy. 3) *All* feedback that provides a largest number of indicators is generally expected to be less effective than feedback that is goal consistent. However, it is an open question as to how trainees under different training goal conditions make use of a large and detailed mass of feedback information.

The experimental design for this study was a 3 x 2 factorial design with three levels of feedback (sequenced mastery, sequenced performance, and all feedback), and two levels of goals (mastery and performance). Training was comprised of three trial blocks, each with three study, practice and feedback cycles. The transfer task was a more difficult and complex version of the trained task comprising a single trial. Learning process and outcome measures included goal commitment, declarative knowledge, structural knowledge, self-efficacy, and basic & strategic task performance. Research participants for this study included 311 undergraduate students from a large mid-western university. Figure 2 presents a summary of the experiment.

Participants were trained and performed on the Tactical Naval Decision Making (TANDEM) task, a research tool developed by the Naval Air Warfare Center Training Systems Division. TANDEM is a PC-based simulation in which subjects are given ambiguous information and required to use that information to make specific decisions regarding the type, threat, and intent of numerous contacts (see Dwyer, Hall, Volpe, and Cannon-Bowers, 1992 for detailed task description). The experimental task used here required subjects to hook, identify, and clear or shoot six targets. The TANDEM simulation provides a single outcome measure based on the number of contacts correctly identified and cleared.

TIME	ACTIVITY	MEASURES
Before Task	Collect individual differences Demonstrate simulation	Cognitive ability Goal orientation
First Trial Block	Goal Manipulations • Mastery vs. Performance Feedback Manipulations • Sequenced mastery vs. • Sequenced performance vs. • All Information	Goal commitment Task performance Decl & Struct knowledge Self-efficacy
Second Trial Block		Goal commitment Task performance
Third Trial Block	Three study, practice, & feedback cycles	Same as Block 1
Transfer Trial	Explain transfer scenario Three study, practice, & feedback cycles	Same as Block 2
After Task	Debrief Questions Dismiss	Evaluation of Feedback Task Motivation

Figure 2: Experiment 1 Summary

Results: Experiment 1. As expected, data analyses indicated that performance goals and feedback yielded the best training performance (Figure 3). That is, individuals assigned to the performance goals and feedback group attained significantly higher TANDEM total scores during training. Although training performance was hindered for individuals in the Mastery goals and feedback group, these individuals showed an increased use of task strategies (e.g., monitoring for perimeter intrusions) during training. It was this concentration on task strategies that enabled those trained with Mastery goals to perform best when transferred to a novel variation of the trained task. That is, adaptive performance on the transfer task was best when trainees had received Mastery goals and the full range of feedback during training (Figure 4). Performance goals (coupled with any type of feedback) and mastery goals with mastery feedback were least effective at transfer.

These results provide clear support for the use of mastery goals coupled with all feedback. The findings for mastery goals coupled with mastery and all feedback were counter to expectations. It appears that the absence of any performance reference for mastery feedback trainees hindered the development of self-efficacy, a key factor enhancing adaptability (Kozlowski et al., 1995), whereas mastery and performance information was available to all feedback trainees. Finer grained analyses will attempt to determine whether mastery goal-all feedback trainees self-sequenced their attention to relevant feedback information. If so, it will identify sequenced mastery goals coupled with mastery *and* performance feedback as a superior training strategy.

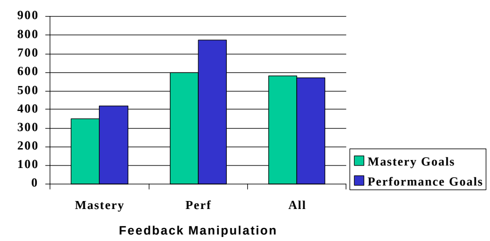

Figure 3: Descriptive Feedback Results: Scores at End of Training

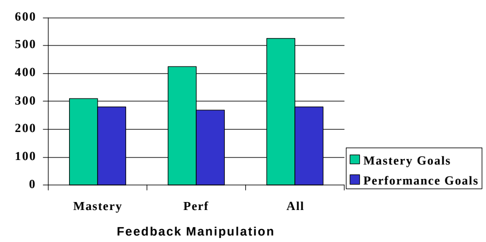

Figure 4: Descriptive Feedback Study: Scores at Transfer

Experiment 2: Interpretation properties

Descriptive feedback is invariably interpreted in an evaluative form. Evaluative feedback involves a comparison of performance (descriptive feedback) to a reference point. In most training environments, the reference is implicitly or explicitly normative (i.e., a comparison of one's own performance to peers). Experiment 2 examined the use of normative feedback presented as either positive, negative, or shifting positive to negative. Bandura's work suggests that normative feedback should always be positive in order to build trainee self-efficacy, promote higher goal setting, and increase trainee motivation (Bandura, 1991). In contrast, control theory (Carver & Scheier, 1990) suggests that moderately negative feedback is best for motivating goal attainment. Most of the research supporting both positions has been conducted using simple physical effort, as opposed to complex cognitively loaded, tasks. What type of normative feedback is best for complex tasks? The present research posited that both types of feedback might be necessary. Too much positive feedback may raise self-efficacy and self-satisfaction to a point where trainees conclude that they have mastered the material, causing them reduce effort to learn prematurely. Too much negative feedback, which is common when learning complex tasks, may yield low self-efficacy and self-satisfaction leading the withdrawal of effort to learn. Thus, initial positive feedback to build self-efficacy, shifting to negative feedback to lower self-satisfaction and stimulate additional effort may be better than either positive or negative feedback alone.

Research Propositions. It was hypothesized that both positive and negative feedback are needed to drive the processes underlying learning and performance for complex tasks. Specifically: 1) Initial positive feedback will allow self-efficacy to develop and prevent withdrawal from the task. 2) Negative feedback later in training will allow trainees to experience some dissatisfaction, without substantial effects on self-efficacy, that will prevent complacency and stimulate continued learning.

The experimental design for this study included three feedback manipulations (all positive, all negative, positive-negative). The experiment comprised of four trial blocks, each consisting of two study, practice and feedback cycles. Feedback provided to the positive-negative group was positive for the first two trial blocks; negative for the last two trial blocks. Measures included self-efficacy, self-satisfaction, goal setting and commitment (effort), time studying (effort), declarative knowledge (learning) and task performance. Research participants for this study included 296 undergraduate students from a large mid-western university. The experimental task for this study was again the TANDEM task. Figure 5 presents a summary of the experiment.

TIME	ACTIVITY	MEASURES
Before Task	Collect individual differences Demonstrate simulation	Cognitive ability Goal orientation
First Trial Block	Feedback Manipulations (All positive vs. All negative vs. Positive-Negative) Two Study, Practice, and Feedback Cycles	Goal setting, Commitment, Task performance, Time spent studying, Satisfaction, Efficacy & Attributions
Second Trial Block		Same as Block 1 plus Declarative Knowledge
Third Trial Block		Same as Block 1
Fourth Trial Block		Same as Block 2
After Task	Debrief Questions Dismiss	Evaluation of Feedback

Figure 5: Experiment Summary

Results: Experiment 2. Data analyses (Figure 6) indicated that participants assigned to the shifting positive-negative condition obtained higher performance scores during training as expected, although results were marginal (p = .07). Finer grained follow-up analyses will attempt to control extraneous variance that may be masking the trends shown in Figure 6. That is, the negative feedback condition exhibited a 5% improvement over positive feedback; shifting feedback exhibited a 5% improvement over negative feedback and a 10% improvement over positive feedback.

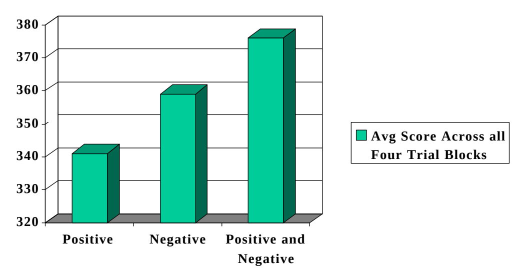

Figure 6: Evaluative Feedback Results: Average Score by Group

The theoretical pathways hypothesized to enhance continued effort were generally supported (Figure 7). That is, positive feedback enhanced self-efficacy, whereas negative feedback operated through self-satisfaction which kept trainees from becoming complaisant with their level of learning. Thus, shifting positive-negative feedback operated through both tracks and led to superior learning and performance as predicted. This is an important scientific contribution as it resolves an apparent theoretical conflict -- social learning and control theory are both correct, but for different reasons.

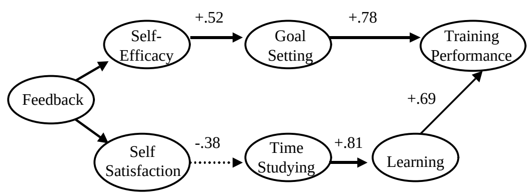

Figure 7: Evaluative Feedback Results: Preliminary Model

CONCLUSIONS/IMPLICATIONS FOR TRAINING

Developing deployable training systems that can reliably deliver the high level of skills associated with adaptive expertise presents several challenges. Shipboard training systems must be able to enhance the acquisition of complex, high level skills that underlie strategic action and adaptability. Shipboard training systems, and their associated instructional supports, must be developmental in order to shift the focus of skill acquisition as learning and performance improve. They also must be flexible enough to allow leaders to customize and adapt the training to deliver skills that are needed for current or anticipated situations.

The model of deployable training and the research presented here offer a number of implications for shipboard training. The ultimate goal for training, particularly in complex environments, is to allow trainees the ability to successfully adapt to changing environments. Theory, research, and practice indicate that information provision, or feedback, is the key leverage point. The research presented here demonstrates how instructional goals and varying provisions of feedback aid in obtaining that goal.

Application implications for deployable training derived from Experiment 1 center on the use of (1) mastery goal orientation, (2) sequenced instructional objectives, and (3) an appropriate combination of mastery and performance relevant feedback. While apparently inhibiting training performance, this approach to instruction appears to provide superior adaptive performance.

Application implications for deployable training derived from Experiment 2 center on the use of normative feedback to appropriately reference the rate of individual skill acquisition. Descriptive feedback provided by technology systems needs to be evaluatively referenced and sequenced to enhance learning and skill acquisition. Thus, the selective provision of normative feedback needs to be an explicit capability of embedded training technologies and/or an instructional skill of leaders/instructors utilizing the technology to accomplish training objectives.

REFERENCES

Ames, C., & Archer, J. (1988). Achievement goals in the classroom: Students' learning strategies and motivational processess. Journal of Educational Psychology, 80, 260-267.

Bandura, A. (1991). Social cognitive theory of self-regulation. Organizational Behavior and Human Decision Processes, 50, 248-287.

Carver, C. S., & Scheier, M. F. (1990). Origins and functions of positive and negative affect: A control-process view. Psychological Bulletin, 97, 19-35.

Catalono, J. F., & Kleiner, B. M. (1984). Distant transfer in coincident timing as a function of variability of practice. Perceptual and Motor Skills, 58, 851-856.

Karoly, P. (1993). Mechanisms of self-regulation: A systems view. Annual review of Psychology, 44, 23-52.

Kozlowski, S. W. J., Gully, S. M., Smith, E. A., Nason, E. R., & Brown, K. G. (1995, May). Sequenced mastery training and advance organizers: Effects on learning, self-efficacy, performance, and generalization. In R. J. Klimoski (Chair), Thinking and feeling while doing: Understanding the learner in the learning process. Symposium conducted at the 10th Annual Conference of the Society for Industrial and Organizational Psychology, Orlando, FL.

Kluger, A. N., & DeNisi, A. (1996). The effects of feedback interventions on performance: A historical review, a meta-analysis, and a preliminary feedback intervention theory. Psychological Bulletin, 119, 254-284.

Latham, G. P., & Locke, E. A. (1991). Self-regulation through goal setting. Organizational Behavior and Human Decision Processes, 50, 212-247.

Schmidt, R. A., & Bjork, R. A. (1992). New conceptualizations of practice: common principles in three paradigms suggest new concepts for training. Psychological Science, 3(4), 207-217.

Schmidt, R. A., Young, D.E., Swinnen, S., & Shapiro, D. C. (1989). Summary knowledge of results for skill acquisition: Support for the guidance hypothesis. Journal of Experimental Psychology: Learning, Memory, and Cognition, 15352-359.

Smith, E. M., Ford, J. K., & Kozlowski, S. W. J. (1997). Building adaptive expertise: Implications for training design. In M. A. Quinones & A. Dudda (Eds.), Training for 21st century technology: Applications of psychological research (pp. 89-118). Washington, DC: APA Books.