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Emergency response training: strategies for enhancing real-world performance

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Abstract

Emergency response training poses three problems that are not encountered in training for routine operations. The first of these is a need to remember the provisions of emergency plans and procedures over long periods of time until an emergency occurs. The second problem is a need to generalize from the specific conditions under which training occurred to the potentially very different conditions of an actual emergency. The third problem is a need to develop effective mechanisms for teamwork under conditions that limit retention and generalization. This article identifies nine ways that emergency response training programs can be modified to improve the effectiveness of nuclear power plant personnel who must respond to accident conditions.

Keywords: Nuclear incidents; Emergency preparedness; Emergency response training

1. Introduction

Disasters occur all too frequently, taking the form of floods, hurricanes, earthquakes, fires, terrorism, and nuclear and hazardous material accidents. These emergency situations can result in great loss of life and property. In recent years, the United States has experienced unprecedented devastation from disasters [1]. The American Red Cross alone typically responds to over 60,000 disasters per year. The number of disasters and situations that could lead to disastrous consequences has been on a steady increase the past 5 years [2].

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In an effort to minimize the potential for and subsequent impact of disasters on life and property, emergency response teams have been organized throughout the United States. These teams serve a number of pre-disaster preparedness functions such as planning, training, and exercising. They also perform emergency response functions such as warning, damage assessment, emergency communications, medical assistance, and search and rescue. Finally, they accomplish post-disaster recovery efforts aimed at restoring the affected community to its pre-disaster state [3]. These teams may be composed of representatives from a variety of federal and state agencies, as well as multiple jurisdictions at the local level. Thus, minimizing the impact of disasters requires effective management of the emergency through coordination of resources and actions from the many different responding organizations.

Training is needed for all of these activities, but emergency response tasks are unique because of uncertainties about what is happening and a need for urgency in response [4]. Thus, emergency response training programs must prepare responders to promptly detect the onset of an emergency, assess its demands, and respond effectively to the situation. This real world performance goal highlights the importance of how well individuals can transfer knowledge, skills, and attitudes (KSAs) and apply behaviors learned in training to performing effectively in actual emergency situations.

The purpose of the present article is to investigate issues of training that have direct relevance to emergency preparedness. We present an overview of the key concepts underlying learning outcomes to provide an organizing framework for this paper. We then examine three key challenges to effective emergency response. For each of these three challenges, we describe specific training and on-the-job strategies for enhancing the effectiveness of emergency preparedness.

2. Learning outcomes

Learning is typically defined as a relatively permanent change in knowledge, skills and/or attitudes produced by some type of experience [5]. As applied to training, learning includes the acquisition of KSAs during the actual training event along with the transfer of training to the job [6]. Supportive transfer of training experiences can lead to a permanent change in KSAs while inhibitors or obstacles in the transfer setting can lead to the minimal impact of training on individual's behaviors and performance on the job. From this perspective, learning and transfer are part of the same continuum. Learning is revealed by and measured by the level of retention and transfer shown on the job.

Learning processes are important in emergency response organizations because they can lead to the development of individual and team expertise. Expertise is defined as the achievement of consistent, superior performance through the development of specialized mental processes acquired through experience and training. Expertise can be built through a systematic, career guidance process that includes formal training programs, on-the-job activities, and other learning experiences. Three issues relevant to expertise include the breadth of expertise, the depth of expertise, and the type of expertise developed.

2.1. Breadth of expertise

Breadth of expertise examines the diversity of training and experience an individual gains as part of a career progression within an organization. On one hand, the focus of learning in an organization can be so narrow that it involves knowing only one's own job. On the other hand, individuals can be encouraged to broaden their learning and development to a wide range of related functional areas.

Learning activities can be categorized as involving the building of technical/job competencies, interpersonal/relationship building competencies and system/process competencies [7]. Technical expertise involves learning specific skills about how to do a particular emergency response job. Learning activities used to acquire technical expertise include formal training and apprenticeship programs, informal on-the-job coaching, and direct feedback from the job itself.

Interpersonal competencies tap into the social context and methods for dealing effectively with others inside and outside a given emergency response unit. Learning activities could include training in areas such as resolving conflicts, communicating effectively, and valuing alternative perspectives.

Systems or process competencies deal with an understanding of the work process that impact each team member's job effectiveness as well as developing a comprehensive view of the emergency response organization's overall mission. Competencies include being willing to strive for continuous improvement, analyze and resolve problems, and adapting to the changing demands of the situation. Learning activities to build expertise in these areas might include job rotation assignments, inter-departmental improvement teams, and formal training on problem solving approaches and work process improvement strategies.

Unfortunately, most emergency response training has tended to focus rather narrowly on the development of technical skills and expertise. While the acquisition of technical skill clearly is a necessary condition, organizations are becoming more aware of the importance of interpersonal and system competencies for effective individual and team performance. Thus, the need to increase the breadth of training to include not only technical but interpersonal and systems skills is being recognized.

2.2. Depth

In addition to the breadth of training content, researchers have begun to identify the depth of knowledge and skill building that is needed to build expertise. Specifically, individuals may have similar levels of experience in an organization and thus be exposed to similar learning opportunities and yet, one person may far outperform the other. This difference highlights the need to understand the depth of learning as well as the content or breadth of learning activities. Depth of expertise consists of three components: (a) knowledge that is highly proceduralized and principled, (b) mental models that are well organized and structured, (c) self-regulatory systems that are well developed [8].

Experts' knowledge is proceduralized and principled, so they not only can recall facts and figures but also can distinguish between situations when that knowledge is applica-

ble and others in which it should not be used. While two individuals may possess the same facts, the one individual with more depth to that learning can do a better job of relating this information to the changing demands of an emergency response situation and predicting what might happen next given the current emergency situation. What we call proceduralized knowledge is often described as a set of conditional-action rules such as ''if Condition A, then Action B''. Thus, given a situation or problem, those with depth to their learning automatically know the proper response and can respond efficiently to many different types of problems.

A second characteristic of experts is the quality of their *mental models* or ways of organizing knowledge. As individuals gain experience with a task or job through formal training, on the job training, and work experiences, they begin to form relational knowledge that defines how things fit together. Experts have well defined mental models that help them see connections between seemingly disparate pieces of information and these connections lead to problem solutions. In particular, experts possess knowledge structures that contain both problem definitions and specific solutions while individuals with less expertise tend to possess separate knowledge structures for problem definition and problem solutions. For example, as computer programmers move from novice to more expert status, they learn to apply different debugging strategies for different types of problems. In addition, expert programmers have learned to mentally group steps within a task so that when they see a particular symptom or problem, they can identify a number of alternative strategies to take and can rank order these in terms of their likelihood of success.

A third characteristic of experts is self-regulation. Self-regulatory skills include the ability to know what are the appropriate strategies to facilitate further knowledge acquisition and to apply their knowledge and skills to solve problems. Experts are able to more accurately monitor or assess their own mental states. Thus, they are more likely to know when they have understood task relevant information, are more likely to discontinue a problem solving strategy that would ultimately prove to be unsuccessful, and are more accurate about judging the difficulty of new problems or situations. Experts are also better able to estimate the number of trials they will need to accomplish as task. For example, good readers are more aware than poorer readers whether they are comprehending the training material as they are reading it. Computer experts have been found to have superior understanding of programming tasks and of ideal working strategies, and have a better awareness of their own performance strategy options. These self-regulatory capabilities enable experts to recognize novelty or change, select potential responses, monitor and evaluate progress, and modify or create different responses to the task if necessary.

2.3. Types of expertise

While breadth and depth of expertise create the potential for effectiveness, differences in the type of expertise have implications for successful application of skills to real world performance. In particular, researchers have noted the critical difference between *routine* and *adaptive* expertise [9,10].

Routine expertise is defined as an internal capability to quickly apply solutions and strategies to well-learned and familiar contexts and situations. This ability is a function of knowledge becoming proceduralized, compiled, and automatized as skills are practiced repeatedly [11]. Automaticity, which involves the ability to perform a skill without conscious thought, allows a person to work on two or more tasks at the same time. For example, a firefighter who can raise a ladder while at the same time reviewing the fire situation to know where to place the ladder would be said to have automatized the skills required for ladder raising. Developing routine expertise is a necessary condition for successful performance on the job. Nevertheless, a sole focus on routine expertise may lead to individuals having difficulty with new or novel problems and situations that involve multiple causes and numerous contextual factors. Routine expertise ignores the development of connections that are required to deal with changing nature of these types of situations.

Adaptive expertise involves the construction of capabilities to integrate simultaneously multiple sources of knowledge for use in addressing changing conditions and unfamiliar situations. With adaptive expertise, individuals can invent new procedures based on their knowledge and make new predictions [12]. The key to this ability to adapt to novel problems is a deeper conceptual understanding of the target domain. This allows adaptive experts to recognize when current procedures must be changed in response to novel circumstances. Adaptive experts realize that the biggest gains in learning and continuous improvement require connections across people. Such experts focus on how to generate creative solutions to problems through the efforts of many.

3. Challenges for emergency preparedness

Discussion of the breadth, depth and type of expertise emphasizes the complex nature of learning processes. Experts acquire necessary knowledge and skills in a variety of ways including formal training. We ''see'' the development of expertise, though, in how effectively an individual applies the knowledge and skills gained in training to complex, real-world situations that might be quite different from those addressed in training.

The focus on real-world performance highlights the fact that changes in KSAs during training are imperfect indicators of learning — their acquisition may indicate only temporary rather than permanent change in the expertise of the trainee. Ensuring the transfer of training and development of expertise over time requires the identification of clear linkages from the expected changes during training to experiences in the workplace and the establishment of conditions that support the application of what has been learned.

Training practitioners and researchers have often bemoaned the so-called ''transfer problem'' — that much of what is learned in training is not applied effectively to the job [13,14]. This transfer ''problem'' of linking what has been learned to real world performance is magnified by the unique challenges faced by emergency training systems designers. Three key challenges are (a) retention of training knowledge and skills over time, given limited opportunities to perform emergency response skills during normal operations; (b) effective generalization of skills learned in training to the significantly

different demands that could arise in an actual emergency; and (c) effective assimilation of individual efforts into a coordinated emergency response.

3.1. Retention issues

Although emergencies are a daily occurrence across the nation, the probability is quite low that a severe accident will occur during the remaining operational life of any given nuclear power plant. Indeed, the likelihood is that the emergency response skills being trained will never have to be used for anything other than practice. Thus, low probability events pose a major problem for training system design. The conventional instructional systems design (ISD) model of training specifies that training should be focused on ''what is to be learned'' [15] and ''real-world performance'' — what behaviors the trainees must exhibit in the work environment [16]. Once these required behaviors have been identified, the KSAs needed to achieve improved behavior on the job must be defined. Finally, a training program must be designed to impart those KSAs.

An underlying assumption of the ISD model is that the KSAs learned in training will be used on the job soon after training. In this way, the new skills can be nurtured in the job environment. Instructional design principles (e.g., practice, variability, and identical elements) have been developed to enhance training transfer to the job [17]. In addition, training evaluation models highlight the importance of determining how well trainees are performing on the job as a key indicator of training success.

With emergency training for nuclear power plant accidents, the assumption that the KSAs being trained will be used or applied immediately on the job does not hold. A key issue, then, is how to design training programs and how to develop on the job activities that help individual not only maintain current knowledge and skill levels but also enhance their knowledge and skills given limited or nonexistent opportunity to perform trained tasks directly on the job.

3.2. Generalization issues

The unpredictable nature of emergencies presents a second challenge to effective training transfer. Even after extensive training, emergency responders are likely to be confronted with unexpected challenges due to unforeseen situational demands [18]. As the experience of the plant operators in the Three Mile Island accident indicates, the response to such demands often must be immediate and executed under high levels of uncertainty. In such conditions, responders often must adapt and improvise behaviors under conditions of high pressure and considerable personal risk.

Traditional training methods typically have focused on training individuals to respond appropriately to routine situations or events that have been identified in advance as the most likely to occur. In fact, training needs assessment techniques that are designed to focus on identifying the most common situations that trainees might be exposed to and then teaching them how to handle those situations. For example, bank tellers can be trained to handle the most common transactions they are likely to encounter. Any unusual transactions that arise are expected to be handled by a worker with more experience. This focus on the common situations and conditions makes sense because it

is not possible to train for every situation one might face on the job — it would be futile to do so and quite costly in terms of training time. Unfortunately, the effective management of complex emergencies demands more from responders than the development of routine expertise. Training that covers the procedures to follow in ''routine'' emergencies is a necessary — but not sufficient — condition for effective emergency response. One does not want emergency responders to blindly follow the emergency plan and procedures when the situation dictates a need for reflective analysis and creative response.

3.3. Teamwork issues

A third challenge to the effective development of emergency response expertise is that the magnitude and complexity of emergency operations require a coordinated response by teams of interdependent members. For example, the large size of a nuclear power plant Emergency Planning Zone (EPZ) may require police departments from many different jurisdictions to coordinate their efforts. The situation is complicated by the fact that many different types of organizations are involved in a typical emergency response. These include governmental organizations (e.g., police, fire, emergency medical, public works, and schools), private organizations (e.g., the Red Cross, hospitals, and nursing homes), and volunteers (e.g., amateur radio) from the affected communities. Each of these responders has specific expertise that is important for handling certain aspects of an emergency. Yet, it is also imperative that the various individuals across departments and agencies work effectively together when an emergency occurs. Optimal emergency management hinges on the cooperation and coordination among individuals. As Wenger et al. [19] have observed, these organizations often are poorly coordinated, requiring each to rely on its own resources and initiatives to handle an emergency. Worse yet, there have been cases in which different organizations expected to use the same resources in incompatible ways [20]).

The challenge is how to develop not only individual expertise on how to handle an emergency but also how to build team skills. To effectively deal with an emergency, teams must respond in a coordinated and unified manner. Thus, training systems designers must consider how best to develop response teams that are capable of coordinated, unified emergency assessment and response. Yet, most training programs focus on building individual knowledge and skills and only hope that somehow individual expertise will lead to effective teamwork.

4. Strategies for improving training effectiveness

The three challenges for effective emergency response training may seem daunting, yet the challenges are real and must be addressed. Fortunately, recent research in training design, knowledge and skill acquisition, and training transfer point to a number of strategies that can be used to address these challenges and lead to more effective training and development. In this section, we describe strategies for dealing with the issues of retention, generalization, and teamwork.

4.1. Improving retention

Traditional training design principles provide a structured and sequenced environment for mastering training content [13]. However successful these traditional design principles may be in fostering short-term learning and immediate retention, they may not produce long-term retention and transfer to more complex task situations [17].

To facilitate longer-term retention and transfer, researchers contend that training must be guided by principles that take into account the characteristics of the trainees and the job conditions. First, trainees often are motivated to learn, but are forced to focus on performing well during training exercises to avoid negative evaluation. Second, most trainees view themselves as capable of self-direction and desire others to see them the same way. Many training programs, though, treat trainees as needing to be controlled and requiring high degrees of structure for learning to occur. Third, trainees desire an active learning and problem solving approach to learning that builds on their own rich and varied experiences, but many training programs focus on information dissemination through lectures. This information dissemination approach reinforces the notion of the learner as a passive rather than an active recipient of new knowledge and skills. In contrast to traditional training principles, the new realities of training for longer term retention have led to alternative design strategies that focus on fostering a mastery orientation, providing learners with control over their own learning, and enhancing the role of the active learner.

4.1.1. Fostering a mastery orientation

Most training for emergency response focuses on getting things ''right''. Tests are scored and drills are evaluated on whether individuals handle the emergency situation in the ''correct'' way. While this evaluation of final performance is needed at some point, researchers have noted the difference between emphasizing performance versus emphasizing learning.

In fact, Dweck [21] has identified two very different goal orientations that people can have towards training activities. *Mastery-oriented* individuals believe that their efforts can lead to improved learning and retention. Individuals with a mastery orientation view ability as something that is malleable. They focus on developing new skills, attempt to understand their tasks, and define their success in terms of challenging self-referenced standards. In contrast, *performance-oriented* individuals believe that ability is demonstrated by performing better than others, even during training tests and practice drills. Moreover, they define success in terms of normative-based standards. Mastery and performance orientations thus represent fundamentally different ideas of success and different reasons for engaging in learning [22].

Ames and Archer [23] contend that trainers can create support for either a mastery- or performance-oriented learning environment. Mastery-oriented environments occur when trainers focus on whether trainees are improving, encourage trainees to try new things, and motivate trainees to try hard to learn. Performance-oriented training encourages normative evaluation (you did better than the average), discourages mistakes, and fosters competitive goals to do better than other individuals or groups.

Researchers have found that learning situations emphasizing performance goals can lead individuals to focus on their ability limitations and attribute any failures to lack of ability. Learning settings emphasizing mastery goals have found that people use more effective learning strategies, prefer challenging tasks, and have a more positive attitude towards learning, feel that success follows from effort, and demonstrate persistence in the face of difficulties.

For example, Kozlowski et al. [24] instructed participants in a mastery goal condition to focus on learning the components of a task, trying out new skills, and exploring new strategies. Individuals in the performance goal condition were instructed to achieve a difficult and specific outcome goal. Results indicated that, compared to trainees with performance goals, trainees with mastery goals were more self-confident, gained more knowledge from training, and were more likely to generalize skills from the training task to a new and more complex transfer task. Similarly, Fisher and Ford [25] found that mastery-oriented trainees put forth more mental effort to learn a task, used more complex learning strategies, and were more likely to learn to learn.

4.1.2. Encouraging learners' control over their own learning

Most training experiences provide a highly structured environment for the trainee. Trainers organize a course, sequence the material, set the pace, and evaluate progress. This structured approach to learning goes counter to an adult learning perspective that highlights most adults' desire some control over the learning process. From this perspective, adults enjoy planning and carrying out their own learning experiences as well as evaluating their own progress.

Recent research attention has been given to the consequences of enhancing learners' control of the training process. With greater control, which has been defined as the extent to which trainees have the opportunity to select the method, timing, practice, and/or feedback of training [26], learners can more actively tailor the training to meet their own needs.

Several hypothesized consequences of learner control are enhanced motivation to learn and retain trained material, as well as the development of a mastery orientation. With more control, learners can become more engaged in the learning process which, in turn, leads them to a deeper understanding of the trained tasks. Increasing learner control also can result in more opportunities to develop and test personal strategies, or to recognize the relationship between one's actions and subsequent effects.

There are many ways to build learner control into training environments. These include the use of interactive software that allows each trainee to select an instructional strategy appropriate to his or her preferred learning style. Web-based training encourages trainees to decide when they have had sufficient time to learn new knowledge or practice skills [27]. In a classroom setting, learners can be given some control over the pace or sequence of instruction or given advice or suggestions for next steps [28]. Over time, the trainee can take on more control over the learning process from the instructor and use the instructor more for mentoring and support.

For example, Ford et al. [29] allowed radar-tracking operators to choose what types of scenario exercises (which varied in difficulty) they wanted to practice. The researchers expected that learners who had greater control would be more active in tailoring the

training to meet their own changing learning needs. Increasing learners' control over the learning process also was expected to lead to a deeper understanding of the task. Results showed that trainees who had more control over training materials were more likely to actively monitor their progress, determine when they were having problems, and adjust their learning strategies. They also were found to have gained greater knowledge, displayed higher skill levels, and were more confident that they could do well on the transfer task than those who had no control over their training. All three learning outcomes — knowledge, skills, and attitudes — predicted transfer of training to a more difficult task.

4.1.3. Enhancing active learning

Adult learning theory highlights the important role of learners as active participants in their own learning processes [30]. Recently, efforts have been made to focus on two ways to facilitate active learning — action learning methods during training and experienced centered learning interventions on the job.

The action learning approach emphasizes that much learning can occur by dealing directly with work-related issues during a formal training session. The focus of the training is to understand and solve complex real-life problems by constructing a smaller, simplified version of the problem. The training experience can include ''what if'' scenarios in which members of different departments or emergency response units are brought together to work simultaneously on a problem. As responders discuss how they would approach the problem, trainers can introduce new situations and problems that must be addressed by the group. Once the scenario is completed, the group can discuss lessons learned about the evolution of the situation. By including experts from all relevant organizations, the trainer can bring to bear a full range of applicable competencies to address the exercise scenario. This combination of experts encourages participants to exercise initiative in creating new problem solutions and implementation plans before an emergency arises. Action learning can lead to creative ideas and innovative strategies for emergency scenarios. It also can lead to increases in participant's self-awareness of skill strengths and weaknesses and lead to feelings of personal accomplishment. Finally, it also can result in more positive group dynamics such as increased group cohesiveness.

For example, the American Red Cross has developed a board game-based simulation to train its staff in emergency operations [31]. While a manager may only work in one area of operations, there are 23 areas or functions that must coordinate action during an emergency operation. Data from training needs assessments had highlighted recurring issues such as needs for more effective information sharing among emergency field operations teams, better coordination of limited resources, and smoother transitions from a localized response to a nationwide network of emergency response personnel and resources.

A simulation designed to focus on these issues featured training scenarios that required the participants make decisions and take actions that have identifiable consequences. The game unfolds through brief situation reports that participants receive at the beginning of each round. There are a number of management tasks embedded into the game that require the participants to complete tasks such as staffing and opening

facilities, assisting clients, and placing volunteers. The simulation is combined with teaching modules that focus on specific issues and skills relevant to successful performance in communications, strategic planning, interpreting reports from the field, and estimating costs. Formal debriefing and the generation of lessons learned that can be applied back on the job provide another layer in the learning process. This action learning perspective has generated very positive evaluations by participants in the Red Cross and has increased the desire for additional simulations where staff can develop their knowledge and skills in a safe learning environment.

Experience-centered learning focuses on the importance of employee job activities that can evoke continuous learning and improvement. Experience-centered learning is based on the assumption that challenges in the job itself can stimulate learning to occur. Thus, opportunities for experience-centered learning must be created for individuals in their job assignments to develop critical competencies for success. According to London [32], there are two types of learning situations: incremental and ''frame-breaking.'' Incremental learning situations are those in which time is provided to clarify role expectations and flexibility for self-paced learning is available. Fundamental competencies are thus gained in a fairly linear fashion. Frame-breaking learning experiences place individuals in difficult positions without much initial preparation. Such situations require the acquisition of a large number of new skills in order to be successful. Frame-breaking requires considerable individual investment with a high potential for learning, but also a high risk for failure. Situations that have been found to have major implications for enhancing learning include features such as having to handle responsibilities that are much broader than previous ones, fixing problems created by others, developing new directions for a workgroup, and handling pressures from external stakeholder groups [33]. This research highlights the need to better understand the learning opportunities inherent in jobs and the need to provide challenging work experiences to stretch individual learning.

4.2. Enhancing generalization

An emerging literature has focused on the need for building adaptive expertise as a key to effectiveness in jobs that are faced with rapidly changing conditions. Emergency response training needs to apply methods that facilitate the development of both routine and adaptive expertise. Adaptability requires more than the acquisition of procedural knowledge and compilation and automaticity of skills. Three design strategies that help to build adaptive capabilities include guided discovery learning, error-based learning, and metacognitive instruction.

4.2.1. Provide opportunities for guided discovery learning

The traditional learning approach uses a deductive approach in which trainees are explicitly instructed on the complete task and its concepts, rules, and strategies. In contrast, recent efforts have stressed the importance of taking an inductive or discovery learning approach to build more learning depth as well as to promote adaptive expertise. In discovery learning, individuals must explore a task or situation to infer and learn the underlying rules, principles, and strategies for effective performance [10].

There are several reasons why discovery learning is beneficial [34]. First, in a discovery learning approach, individuals typically are more motivated to learn. This increased motivation occurs due to the fact that the trainee is responsible for generating correct task strategies and, thus, is more actively engaged in learning. Second, discovery learning allows learners to use hypothesis testing and problem solving learning strategies. In contrast to the traditional deductive learning approach, this active process requires more conscious attention for its application and adds depth to the learning process. Third, individuals engaged in exploratory learning also are likely to experiment with a greater range of strategies. The development of these strategies for discovering information helps individuals to identify novel or unpredictable job situations and, thus, promote a search for new ways to approach the situation. The new knowledge that is acquired by trying out alternative strategies can then become better integrated with the learner's existing knowledge.

There are several ways to implement a guided discovery approach to learning for perceptual-motor and problem solving tasks. Guidance can include the following types: giving partial answers to problems, providing leading questions or hints to the learner, varying the size of steps in instruction (part versus whole learning), and providing prompts without giving solutions. In addition, guidance can be given to learners on how to form hypotheses and test out these ideas in an effective way [35,36].

For example, with emergency response training, trainees can be presented with case studies of previous emergency situations and asked to draw inferences about effective and ineffective responses to these situations. From these specific incidents, general principles of effective response can be generated and discussed.

4.2.2. Include error-based learning activities

Traditional training methods seek to minimize incorrect responses and to focus on modeling only effective behaviors and performance. More recent efforts have focused on designing errors into training as a learning experience. For example, Baldwin [37] showed one group of trainees only a positive (correct) model of assertiveness behaviors and another group of trainees both positive and negative (incorrect) models. The trainees receiving the mixed mode (both correct and incorrect models) demonstrated greater learning and training transfer than those just receiving the positive model.

The research literature has suggested three benefits of error training. First, incorporating ''error filled'' experiences into training allows learners to develop more complex mental models about the behaviors to be trained. Second, errors increase a learner's attention because they signal unexpected events. Third, errors alert individuals to incorrect assumptions in their knowledge structure. In connection with this third benefit of error training, Ivancic and Hesketh [38] stressed the importance of training individuals about the likely errors they would commit, examples of what they should not do, and information about the limits of a model or strategy. These researchers contended that error training must also contain the incorporation of error management strategies. Such strategies allow learners to cope with and learn from error situations that otherwise might have negative motivational effects. For example, trainees can be told in advance that making errors actually is an important training goal. Because people tend to view

errors as a negative event, training needs to highlight the beneficial effects of errors for learning and the valuable information that these errors provide.

4.2.3. Develop metacognitive skills

A critical component affecting the generalizability of training is the capability of learners to regulate their own learning. This capacity for self-regulation of learning, known as metacognition, consists of three components — planning, monitoring, and evaluating [39]. Planning involves the learner's analysis of a learning situation and determination of what strategy is likely to lead to successful acquisition of trained knowledge and skills. Monitoring involves learners' active attempts to track their allocation of attention, as well as their assessment of how well they are comprehending the material. Evaluation involves learners' active assessment of their success in skill acquisition and their likelihood of successfully transferring the learned skills to the job. This self-evaluation component also includes the ability to correct ineffective learning strategies. Thus, those who are more aware of their cognitive processes and are more effective at monitoring and evaluating their strategies concurrently with performing a complex new task are more likely to be successful [40].

Researchers contend that increasing a learner's metacognitive processing during training will promote a deeper processing of information by assisting them to integrate material and identify interrelationships among training concepts [41,42]. Metacognitive processing can be facilitated during training by encouraging learners to identify goals, generate new ideas, elaborate on existing ideas, and strive for greater understanding. For example, trainees could be asked set challenging learning goals, visualize possible courses of action, reflect on how much they have learned, and consider if alternative learning strategies might be more effective.

Research supports the contention that incorporating metacognitive activities into instruction can facilitate knowledge and skill acquisition as well as aid in the generalization of training to the job. For example, Volet [43] found that by the end of a computer programming course, college students who were taught metacognitive activities (how to monitor and evaluate one's self) received better grades than the control group and were better at applying their knowledge to solve new problems. Ford et al. [29] found that trainees who initiated more metacognitive activity (planning, monitoring, and self evaluation) not only learned more, but also were better able to handle a more complex transfer task.

4.3. Enhancing teamwork

Teams can best be understood as a network of roles and responsibilities whose core is the system of dyadic linkage among team members [44]. To perform effectively, all team members must understand how their actions affect and are affected by each of the other team members. The evolution from a collection of individuals into an effective team is predicated on adequate development of a number of team competencies. Team competencies are the KSAs necessary for effective performance of the team's task. While similar in nature to the KSA approach typically applied to individual training,

team competencies are quite distinct from individual competencies, not merely aggregates of individual-level counterparts as is often believed [45]. Thus, individual competency is a necessary, but not sufficient, condition for effective team performance [46]. Indeed, the relationship between average individual skill level and team performance is generally found to be small [47].

Recent reviews of the team literature indicate a number of team competencies that can be expected to play a large role in the effectiveness of emergency response teams [48,49]. Examples include knowledge competencies such as shared mental models and role knowledge, skill competencies such as adaptability and coordination, and attitude competencies such as assertiveness and collective efficacy. In the discussion that follows, we will address in greater detail three factors that can facilitate the development of adaptive emergency response teams, as well as provide specific steps that can be taken to facilitate the development of these team competencies within an emergency response operation.

4.3.1. Build teamwork skills

Cannon-Bowers et al. [48] have made the distinction between taskwork and teamwork skills. Taskwork skills are directly related to the execution of the task at hand. In contrast, teamwork skills are those related specifically to the interaction among team members, largely independent of the task to be performed. Their recent review of the teamwork skills literature identified a set of core teamwork dimensions, including (a) adaptability, (b) situational awareness, (c) performance monitoring, (d) interpersonal skills, (e) coordination skills, (f) communication skills, (g) assertiveness, and (h) decision making skills. Research suggests that teamwork skills are a critical determinant of team performance, particularly under conditions of high workload and high stress in which emergency response teams generally must operate [50]. Under these conditions, effective teamwork is essential to cope with the situation successfully. Yet, the high stress and attentional demands lead many teams to shift their focus toward taskwork (i.e. individual task performance), often to the detriment of teamwork and, consequently, team performance. Thus, emergency response teams should benefit greatly from teamwork skills training.

In an exploration of decision making in offshore oil platform emergencies, Flin et al. [51] highlighted the need for effective teamwork skills in emergency response and proposed Crew Resource Management (CRM) as a useful framework for developing these skills. CRM has been defined as a set of teamwork competencies that allow an entire team to cope effectively with situational demands that would overwhelm any individual team member [52]. These researchers have developed a methodology for designing CRM training programs that begins with the identification of the mission requirements and procedures. This is followed by an assessment of the coordination demands (i.e. specific tasks requiring teamwork). These tasks are then linked through theories of team performance to derive the specific competencies to be trained. Each competency is translated into a training objective that can be evaluated objectively. The next step is to determine the instructional delivery method (i.e. lecture, video). Following that, specific emergency response scenarios are developed to provide opportunities for trainees to practice each competency and trainers to assess whether the targeted

behaviors are demonstrated sufficiently. Based upon this assessment, trainers can provide constructive feedback concerning which team behaviors were and were not performed successfully. Finally, the training is evaluated to determine its effectiveness at increasing the targeted competencies on the job.

Recent evaluations of CRM training programs have provided encouraging results regarding its effectiveness. CRM training has been shown to yield as much as a 20% increase in teamwork behaviors in teams trained under this method. For example, Salas et al. [52] found that CRM training led to increases in positive attitudes toward teamwork, knowledge of teamwork principles, and demonstration of teamwork competencies in a simulated mission. The difference between the treatment and control groups in their levels of teamwork behavior was particularly large in high workload conditions. Moreover, CRM training was found to be effective for both new aviators and those with previous experience performing their tasks as a team. Additionally, aviators who occupied different positions within their teams benefited from the same training program.

4.3.2. Develop shared mental models

One team knowledge competency that has become the focus of increased attention in the team training literature is the concept of shared mental models. Mental models are ''the mechanisms whereby humans generate descriptions of system purpose and form, explanations of system functioning and observed system states, and predictions of future system states'' ([53], p. 351). Shared mental models refer to organized knowledge that is common among the team members [54]. A shared mental model consists of the overlap among individual team members' mental models that facilitates their adaptation to the changing demands of the task and the accompanying demands of their teammates.

The mental model construct has been implicated as a significant determinant of success in dealing with emergency situations. For example, Flin et al. [51] noted the importance of shared mental models among interdependent members of a response team, especially when they must perform their tasks without overt communication. However, it is not possible, nor is it necessary, for a team of even modest size (i.e. five or more members) to possess completely isomorphic (i.e., identical) models. Rather, what is needed are compatible models, wherein aspects of the mental models critical to team coordination are shared and each member possesses a submodel that is uniquely tailored to the requirements of his or her unique tasks [55]. Further, team members may possess multiple mental models, including models of the equipment, task requirements, team member roles, relationships between team members, and typical member interactions [50]. Given the complexity of many emergency response organizations, mental models of members' roles and responsibilities — including knowledge of who has and who needs particular pieces of information (i.e. transactive memory [56]) — may play a large role in determining team effectiveness.

As previously indicated, shared mental models are particularly critical when overt communication is not possible. In such instances, the team members must rely on a pre-existing knowledge base and common expectations of how the team must perform. When the task is dynamic and emergent, the team often must restructure the network of roles and responsibilities in order to cope [44]. This reconstruction is predicated on an

accurate representation of the roles, responsibilities, and information and coordination requirements of other team members — a concept referred to as interpositional knowledge [50]. One method for developing shared mental models is cross training, which requires team members to learn about the roles of other team members. The locus of cross training's effectiveness is thought to be in the development of interpositional knowledge which, in turn, can facilitate implicit coordination among team members and greater team adaptability [57].

Cross training can take several forms, including positional clarification, positional modeling, and positional rotation [58]. In positional clarification, team members receive verbal or written information on various facets of their teammates' jobs. In positional modeling, the duties of one's teammates are discussed and observed. Finally, positional rotation is experientially based training, wherein team members actually perform the duties of other team members to get a hands-on perspective of their roles, responsibilities, and coordination demands. The form of cross-training utilized should correspond to the level of interdependence of the team, with positional clarification being sufficient for teams with minimal interdependence, and positional rotation appropriate for highly interdependent teams [58]. It is important to note that, although team members may acquire a great deal of knowledge of their teammates' duties, the goal of cross training generally is not to develop intersubstitutability among all members of the team. Rather, the goal is for all team members to acquire a working knowledge of the tasks performed by their teammates and the interconnections among these tasks.

Studies have provided empirical support for the utility of cross training as a means of enhancing team-effectiveness [57,49]. For example, Volpe et al. [57] found that two-member teams operating a PC flight simulator demonstrated greater overall teamwork, more efficient communication strategies, and greater team performance when provided with positional clarification than when trained only on their individual duties. Extending this initial finding to situations in which emergency response teams must operate, Cannon-Bowers et al. [49] found that the benefits of cross training were greatest under high-workload situations.

4.3.3. Develop team leaders

Although leaders traditionally have been conceived of as supervisors or directors of performance, there has been increasing acceptance of a team leader's role as a facilitator of team development and continuous learning [59]. This developmental role pertains especially to actions taken by the leader during the formation and evolution of the team to foster its development into an effective unit [60]. Although the leader's developmental role is particularly salient during the initial stages of team development, it should extend throughout the life of the team.

The earliest stages of team formation are characterized by high ambiguity and self-awareness, as individual team members seek social information relevant to the group's goals, climate, and norms [44]. Individuals cannot focus their attention on taskwork until these teamwork issues have been resolved [61]. The team leader can play a vital role during this phase by explicitly defining the social structure and promoting an environment of open communication and self-disclosure. Additionally, by filtering and interpreting information, the team leader can help to facilitate the role negotiation

process [62,63]. This process results in specific role knowledge concerning the other team members with which each individual must interact, what inputs and outputs are required of this interaction, and when particular role behaviors should be performed. Role knowledge, in turn, provides the foundation for adaptive team performance.

Tannenbaum et al. [64] have emphasized two means by which a team leader can promote team learning and performance — pre-briefs and post-action reviews. A pre-brief is a team meeting generally held prior to task practice or performance during which the team prepares for the upcoming activity. Pre-briefs provide the team leader and members an opportunity to accomplish such activities as setting individual and team-level goals, discussing performance strategies, clarifying roles and responsibilities, and anticipating potential problems. Pre-briefs also can be used to explicate the linkages between individual roles and those of their team members. Additionally, specific strategies can be developed for a variety of likely contingencies, allowing all team members to form common expectations about how the others will respond. As the name implies, pre-briefs generally are conducted prior to a practice or performance episode, but team leaders also can capitalize on low-workload periods to engage in such structuring activities. Indeed, a distinguishing factor between high- and low-performing aircraft crews was the extent to which they utilized low-workload periods to discuss how they would handle emergency situations [65].

Upon completion of a practice or performance episode, a post-action review can be utilized to critique individual and team performance, as well as summarize lessons learned that can guide future performance. A central component of the post-action review is the provision of both individual- and group-level feedback. Feedback focuses team members on critical aspects of the task and provides a means of regulating progress towards a goal [66,67]. Two critical principles should be kept in mind while conducting post-action reviews. First, it is important to foster a climate of openness and trust, so that team members can feel comfortable admitting confusion and mistakes that occurred during performance. One means of building such a climate is for the team leader to provide a self-critique early in the post-action review. Such actions can serve as a model for team members to emulate, especially if this is accompanied by a willingness to accept open feedback from the team members (e.g., criticism as well as praise).

The second critical principle when conducting post-action reviews is that diagnostic (i.e. process) feedback is preferable to performance (i.e. outcome) feedback, particularly early in team development [60]. Process feedback is more useful for directing team members' attention to specific areas of performance, as well as emphasizing *how* performance can be improved. That is, process feedback should focus on the implications of performance errors for specific provisions of the emergency plans, procedures, and training programs that can be targeted for later revision.

In contrast, providing only outcome feedback during early skill acquisition may foster a performance orientation that focuses team members on blaming each other for poor performance, rather than learning from the mistakes that were made. Thus, providing outcome feedback early in team development may undermine the benefits of setting mastery or learning goals. While the detrimental effects of performance goals for individual skill acquisition have been demonstrated [68,24], this may have even greater

consequences on team learning. The coordination demands of a team task require greater use of team members' cognitive resources and provide more opportunities for errors. Performance goals and outcome feedback may lead team members to focus solely on their own tasks rather than on coordinating and communicating with team members. Additionally, because performance goals often lead to reduced self-efficacy, the large number of errors that are likely to occur early in team development may cause team members to withdraw from the task.

5. Summary

Emergency response training poses a number of problems that are not encountered in training for routine operations. The first of these is a need to retain material learned in training over long periods of time until an emergency occurs, while the second is a need to generalize from the specific conditions under which training occurred to the unforeseen conditions in which an emergency response actually is required. The third significant problem is a need to develop effective mechanisms for teamwork when team members must perform interdependent tasks under high workload, severe time pressure, and high accuracy requirements.

These problems can be overcome by means of nine different training strategies. The problem of long-term retention can be addressed by helping trainees to adopt a mastery- rather than a performance-oriented learning strategy, by encouraging them to assume greater control over the learning process, and by promoting active learning. The problem of generalization can be overcome by providing opportunities for guided discovery learning, incorporating error-based learning activities into training, and providing for the development of metacognitive skills. Finally, teamwork can be improved by specifically addressing teamwork skills in training, assisting trainees in their development of shared mental models, and providing exercises that develop team leadership skills. If emergency response training programs incorporate these features, then emergency responders will be able to work more effectively with each other to protect the public health and safety.

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