Developing adaptive performance:

A conceptual model to guide simulation-based training design

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ABSTRACT

Introduction: Effective emergency department care requires individuals and teams to adapt to changes in patient condition, team factors, environmental issues, and system-level challenges. Adaptability is often listed as an important skill for emergency medicine physicians; however, conceptual models describing the processes involved in adaptive performance have not been translated for healthcare settings. Similarly, educators have not described training design strategies that support the development of adaptive performance.

Methods: We examined the team science and healthcare literature for key concepts in adaptive performance, healthcare team performance, and diagnostic decision-making. Using expert consensus, we integrated these concepts to develop the Team Adaptive Performance model and to identify training design approaches that support the development of adaptability.

Results: We identify 9 training principles supported by the team adaptive performance model and the adaptive learning system. Each training principle is accompanied by recommendations and mechanisms for implementation in emergency medicine simulation-based education.

Conclusion: Training experiences can be designed to target processes that support adaptive performance.

INTRODUCTION

Team adaptability is necessary for effective emergency department health care team performance. *Adaptability* is defined as the changes in processes (cognitive, affective, and behavioral) individuals and teams make in response to unanticipated changes in the task, environment, or team.[1] In other words, teams need to be able to identify situations that require change, and then efficiently and appropriately modify their processes. This results in an "adaptive cycle" that may repeat frequently depending upon the degree of uncertainty and instability present in the clinical situation.[2] In action teams, such as emergency resuscitation teams, trauma teams, and disaster management teams, success often depends upon the ability to alter behavior in response to unforeseen changes without the ability to pause their current work and plan a course of action.[3] Teams without adaptive capabilities function in a reactive mode fraught with potential safety threats and error risks.[4,5]

Interventions that incorporate active learning strategies increase adaptive capacity in non-health care contexts.[6-11] Active learning approaches develop the underlying behavioral, cognitive, and motivational processes needed to support the application of existing knowledge and skills to unfamiliar situations. To be effective, these interventions should (a) represent the clinical (i.e., performance) context and (b) prompt adaptive behaviors in response to dynamic changes in the patient and the environment.[12] Additionally, training design and implementation should consider the individual, team, and task variables that impact training effectiveness and team performance.[13] Current models of adaptability, training, and team effectiveness exist; however, these models have not been integrated and used to guide development and implementation of health care team training.[1]

Rigorously designed simulation systems can support active learning experiences and improve adaptability and performance in both individuals and teams.[6,14,15] Simulations allow manipulation of the tasks or problems experienced within the clinical environment to stimulate critical, dynamic decision-making processes.[16] Technological advances have expanded the breadth and depth of simulation-based training in healthcare; however, there remain gaps in identifying and implementing key underlying instructional design elements that support the development of adaptive performance. Existing frameworks and conceptual models of team adaptation and adaptive performance training within the team science research have not been adequately translated for healthcare application.

Our overall objective is to introduce a conceptual model for adaptive performance and describe a training framework that supports the development of adaptability. We then translate evidence-based principles from the team and instructional design sciences to simulation-based training recommendations. This framework and set of principles can be applied to a variety of learners, simulation modalities, and clinical situations.

CONCEPTUAL MODELS AND GUIDING PRINCIPLES

The authors were part of an expert group including organizational psychologists (4), emergency medicine providers (3), and simulation science experts (2). This group applied existing literature to identify model components and guiding principles.

Adaptive Performance Cycle – What is adaptation in emergency healthcare teams?

Adaptive performance models exist outside of the healthcare team literature. Team adaptability is cited as one of 5 coordinating mechanisms of teamwork.[17] Several concepts commonly discussed in healthcare team research, e.g., diagnostic decision-making,[18] planning,[19] monitoring, are inherently part of team performance adaptation. Burke, et al present a model of team adaptation that describes how individual and task characteristics impact the adaptive cycle and resulting outputs.[2] This high-level overview serves as a foundation for understanding adaptation within healthcare teams. In Figure 1, we present a model integrating Burke, et al.'s overview with existing conceptual frameworks of the diagnostic process,[18] team adaptation,[2] team effectiveness.[4,20,21] The purpose of this model, described in more detail below, is to facilitate the assessment and training of adaptive performance.

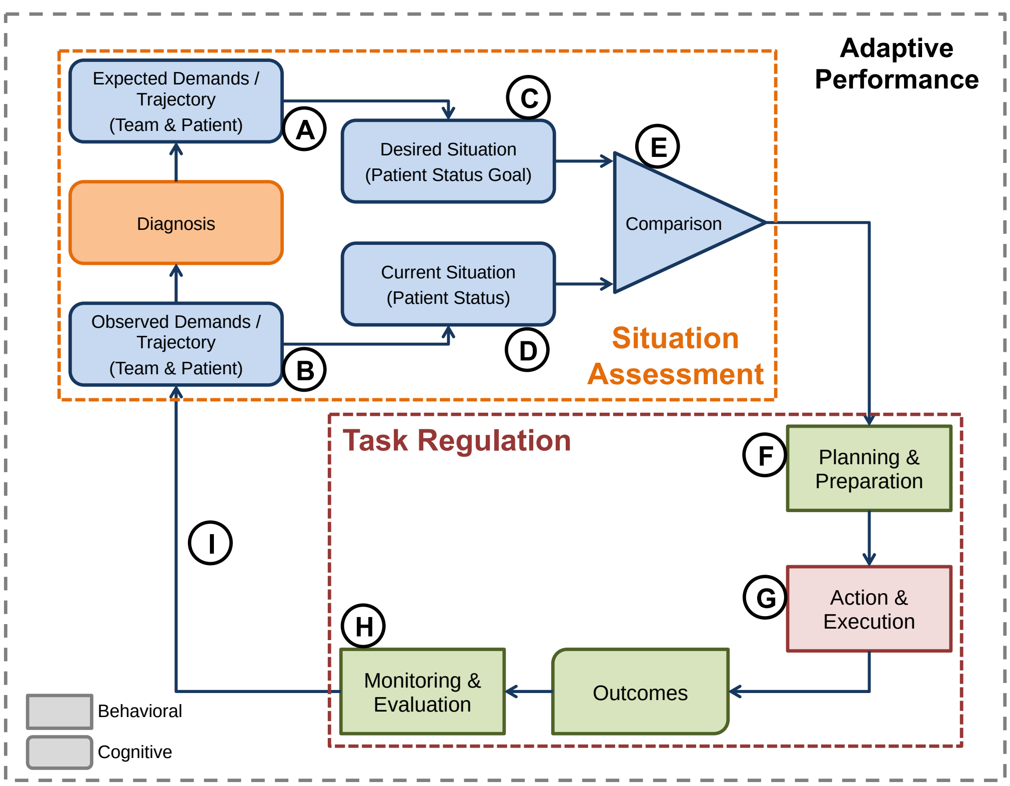

FIGURE 1. Team adaptive performance model

The Team Adaptive Performance model (Figure 1) reflects the cognitive and behavioral process components of team performance. Cognition is represented by the team's efforts to make sense of the situation (Situation Assessment). The team must use existing data/observations to identify the patient- and team-related tasks and demands (A,B). This information is then used to develop a differential diagnosis. Based on this/these diagnoses, the team has expectations regarding how the patient will respond to treatments and how their condition will evolve over time. The team continuously compares this "expected" state (C) to the "observed" state (D) of the patient. This comparison (E) informs the team and helps regulate the team processes that regulate task performance (Task Regulation). If the team notes a mismatch between expected patient improvement and current patient condition, this should prompt the team to review their plan (F), make adjustments, and execute the modified plan (G). The results of these new actions should be monitored and evaluated (H). The observations made during evaluation become the input for the next adaptive cycle (I). In a rapidly evolving patient resuscitation, this cycle repeats continuously to ensure the team is adapting to the unstable patient/team/environment.

The cycle of adaptive performance highlights several key factors relevant to training. First, "adaptability" is not a standalone skill or behavior. Rather, it is the result of multiple cognitive and behavioral processes that must be trained together. The capacity to be adaptive is facilitated and developed by helping individuals and/or teams learn how to carry out the actions shown in this model more effectively. Second, improving adaptive performance requires that training environments provide appropriate clinical and environmental cues to prompt necessary cognitive and behavioral processes. Simulation-based instruction provides an opportunity to present stimuli that elicit specific aspects of situation assessment and task regulation. Third, assessment metrics can be designed to specifically evaluate key adaptive behaviors. The model provides a map to help identify key cognitive, behavioral, and performance outcomes that can be used to measure adaptive performance changes related to training interventions.

Training concepts that facilitate the development of adaptive performance

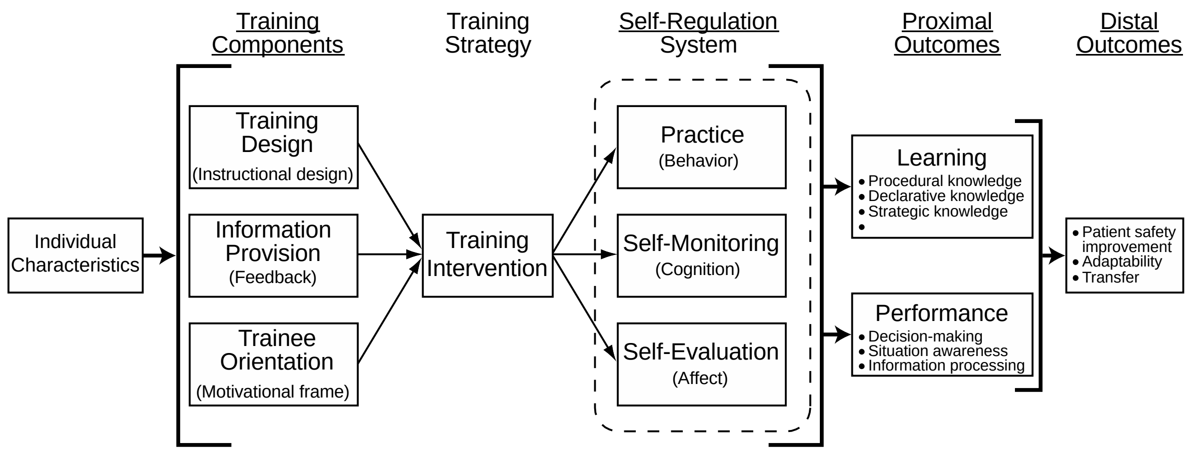

FIGURE 2. Adaptive Learning System

Medical educators can leverage specific design elements to target the development of adaptive processes in individuals. The Adaptive Learning System (ALS; Figure 2) design framework can guide the development, implementation, and outcome evaluation of active learning interventions that target adaptive expertise.[13] Briefly, the ALS is grounded in a self-regulatory model of learning, motivation, and performance.[22,23] Self-regulation requires learners to monitor the differences between goals and current states.[24] That is, they must recognize when they are not progressing adequately toward meeting their goals and redirect effort and resources to remedy these shortcomings (i.e., adapt). Data from empirical studies support the validity of the ALS heuristic as a framework for developing individual training that improves self-regulation and adaptation.[7,9]

We combined foundational concepts from simulation, diagnostic decision-making, adaptive performance, and the ALS framework to develop a set of design principles. These principles are aimed at facilitating learner behaviors (e.g., monitoring, reflection, contingent decision-making) that are central to effective adaptation.[7,25] Here we present training design guidelines based on the ALS framework and supported by research in team science. These recommendations are flexible, allowing for in situ training opportunities that involve true interdisciplinary teams (i.e., nurses, physicians, medical assistants, etc.) as well as training with a single type of learner (e.g., residents) in which other disciplines' roles are scripted. In emergency medicine this could involve emergency department interdisciplinary in situ simulations of critical patient care events or resident-specific training where the objectives and debriefing points center on adaptation.

- **Use pre-training materials to provide appropriate orientation to trainees.[13,26]**

  Pre-training materials presented at the start of training provide an initial organizing structure of the subject matter discussed in training. Pre-training materials provide conceptual information, help to build connections between similar ideas, and delineate different concepts from one another. Trainees who use or begin to develop their own pre-training materials are more likely to adaptively transfer knowledge and skills.

  a. Inform trainees about training focus. This does not necessarily mean informing them of critical content planned for simulations; rather, tell trainees they will be focusing on team (or individual) skills
  b. Suggest that trainees consider personal strengths and weaknesses prior to coming to training.

- **Encourage trainees to adopt a learning goal orientation during training.[12,23]**

  Training design that promotes a learning goal orientation (e.g., a focus on self-improvement and task mastery in achievement situations) has been linked to positive training outcomes, such as goal setting, self-regulatory activities, learning, and performance. This is in stark contrast to promoting a performance goal orientation (e.g., a focus on demonstrating ability to others in achievement situations), which has been shown to negatively relate to goal striving processes and performance. Training experiences that emphasize how learning outcomes/capabilities are evolving (e.g., incorporating “feedforward” information that emphasize developmental goals/targets in addition to traditional feedback information that summarizes what has been accomplished) can be especially helpful for promoting a goal orientation for learners more conducive to developing adaptive capacities.

  a. Encourage trainees to set goals specific to learning objectives
  b. Establish a learning environment that supports psychological safety.[27]
  c. Encourage trainees to view training as "learning" rather than "evaluation."[13]

- **Structure training material so that instruction proceeds from general to detailed, simple to complex.[1,28]**

- **Provide trainees with strategy instruction only after appropriate foundational knowledge has been developed.[29,30]**

Successful team adaptation requires integrating, coordinating, and regulating a variety of different skills, resources, and members. Developing the capacities to manage these processes should be scaffolded to allow learners to first build basic competencies and then practice/engage in more complex applications. Note that this also applies to actively training members as part of intact teams -- team-based training designed to enhance adaptability is complex and should be postponed until learners have engaged in more foundational training exercises. Without achieving proficiency in the basic and procedural knowledge necessary to carry out core task/job requirements in a domain, efforts to improve the adaptation process will be less effective. For more advanced learners, with existing knowledge of adaptive performance, complexity can be increased to include issues such as equipment failures, resource limitations, and multi-patient management.

a. Assess individuals for team-based simulation "readiness".[4]
b. Use low fidelity non-clinical simulations to begin building team skills while individuals are still developing clinical knowledge.[31]
c. Team-based simulations should initially use basic clinical scenarios rather than unusual or highly complex situations. Once basic team skills have transferred from "non-clinical" simulations (above) to straightforward clinical issues, more complex team and environmental issues can be added.[13]
d. Use an event-based approach to training (EBAT) to create a simulation experience where modules can be added to model more complexity as well as to target specific team skills.[32] This methodology is based on the design and placement of discreet event sets within the simulation-based exercise. Events begin with a “trigger” to activate the learner(s) and create the requirement for adaptation to changes in the task or environment. Cues can be altered or removed to challenge learners in a way that is appropriate for their training level. Thus, training does not rely on chance encounters but rather creates a need for adaptive performance.[33]

- **Trainees presented with extremely difficult problems that appear unsolvable should be assisted in making some consistent progress during training.[34]**

The structure of the training environment and practice opportunities for team adaptability should not be "sink or swim," especially during initial stages of practice. Feedback and direction that actively guides teams through how to think through a complex task and make decisions about resources is a critical foundation of team adaptability training. Providing guidance that prompts teams to explore options for task completion during training helps to avoid discouragement, anxiety, and abandonment of effort.

a. Use triggers and backup triggers during simulations, i.e., EBAT techniques, to allow learners to attempt the behavior and, if unsuccessful, observe an "expert" (embedded participant) execute the behavior with success.[35]
b. Teams or learners that may lack certain clinical knowledge should be encouraged to seek assistance for help at any time. Using embedded participants as "mentors" can not only assist learners through difficult tasks but also will build comfort with seeking help from other team members and those outside the team.

- **Simulations should represent a wide variety of clinical events to maximize retention and transfer[12]**

Whereas early stages of training are enhanced by repetition and rehearsal (i.e., developing declarative & procedural knowledge), advanced stages of training are enhanced by exposing trainees to a diverse array of scenarios in which to apply their skills. It is particularly critical to expose trainees to situations where previously learned, frequently used, and/or typically reliable courses of action are ineffective. Providing variability in practice trials promotes the development of broader associative knowledge structures and contingency-based thinking.

a. Shorten intervals between prompts to increase time pressures as appropriate.
b. Use embedded participants as team members to add interpersonal challenges.
c. Build in environmental challenges (e.g., additional patients, equipment failure) to increase complexity.

- **Training should be permissive of, embrace, and even encourage errors made by learners during training[1]**

Errors are an inevitable component of real-world performance. Errorless training leads to effective training performance but is often related to poor training transfer.[36,37] Although errors during training should be brought to learners' attention, learning that is focused on error management as opposed to error prevention is more successful. Framing training as an opportunity to make and learn from errors encourages trainees to develop problem-solving or hypothesis-testing skills and strategies for managing affective responses (e.g., frustration and anxiety).

a. Use embedded participants to create opportunity for errors during simulations. This technique requires learner familiarity with embedded participants and an understanding of their role as a team member. This requires considerable expertise in simulation design, prebriefing, and debriefing to ensure learners have trust in the process and understand how the educators use embedded participants. Be sure that “errors” meet a minimum level of psychological fidelity for learners. If embedded participants are not used as part of normal simulation training, this may not be an ideal approach for learners at said institution.
b. During debriefing allow participants to identify errors and near-error, focusing on how the team managed the situation and what could be applied to future events.[13,38]

- **Incorporate lessons on how to alter coordination strategies in training.[39]**

When task demands are low, trainees should learn to discuss possible problems that could arise later in the task. By discussing their coordination strategies during this period, they will likely reduce the amount of communication necessary to achieve successful team performance later and allow them to be adaptive when novel problems arise in the environment.

a. Encourage learners to develop contingency plans. This could be done through briefs, prompts, or even debriefs provided the time between simulations is short.[19]
b. Discuss team member understanding and mental model development during debriefing to help reinforce the importance of discussing and practicing team coordination.[39]

- **Include Safety II principles during debriefing to support the development of adaptive capacity[40]**

Existing safety improvement efforts focus largely on prevention of error by identifying what went wrong and “fixing” it. This approach, termed *Safety-I,* assumes an idealized view of work where there are simple, rational processes and error results directly from failure(s) within the system.[41] A *Safety-II (resilience)* approach changes the focus to enabling what goes right.[42] Work is viewed as complex, emerging, and contingent upon a large and variable number of factors. This complementary view sees errors and successes as originating from adaptation in performance. Safety-II recognizes that individuals must adapt within complex environments to continue functioning effectively in a dynamic system.[43]

Bentley, et al provide a rationale and an outline for utilizing Safety II principles in debriefing.[40] The overall focus encourages learners to understand and acknowledge normal workflow (i.e., work as done) and recognize how/why adaptation did or did not occur. Balancing Safety I and Safety II principles in debriefing can help learners improve performance and identify team/system level issues that threaten safety.

a. Identify how tasks were accomplished, and how such work is normally executed during a clinical situation.
b. Identify any near misses and explain what occurred to prevent actual harm.

DISCUSSION

The need to effectively adapt to change is well recognized in teams performing in high-risk domains,[44,45] including healthcare.[46-48] Training can improve adaptive performance in teams, resulting in more effective performance under unstable conditions. In non-healthcare domains, simulation-based training has been shown to be a highly effective adaptive performance training modality.[8] Healthcare educators can incorporate simulation-based training elements that specifically target adaptive cognition and behaviors with the goal of improving patient safety and overall effectiveness.

Applying the guidelines presented in this manuscript does not necessarily require the development of new curricula. Rather, existing training can be modified to include elements that support learner orientation and help learners frame their training appropriately. Simulations can be reconfigured to include clear prompts and triggers that support adaptive performance and guide learners during early training efforts. Such simulation training that provides planned disruption, or non-routine events, can force individuals and teams to develop flexible, coordinating behaviors that support adaptation under dynamic, uncertain conditions.[14]

Event-based training design[32] is central to the design of adaptive performance training. The ability to facilitate the specific behaviors of interest allows educators to create the need for adaptation. Additionally, the ability to easily insert and remove certain cues enables training to accommodate learners at multiple different levels. When combined with debriefing that includes Safety II focus, learners can develop critical understanding about how they adapt to novel or complex situations to provide safe patient care.

To advance the science of adaptive performance in healthcare, it will be important to develop and evaluate process and performance level metrics. Existing adaptive performance metrics in healthcare are limited, mainly focusing on the coordination required for adaptation.[49,50] It will be important to further explore measurement of the cognitive skills and monitoring behaviors that support adaptive performance. A comprehensive approach to measurement of adaptation at the individual and team levels will help guide training curricula in emergency medicine.

CONCLUSION

This manuscript provides a starting point for developing theoretically grounded adaptive performance training. Such training is likely important across healthcare domains but has particular relevance for emergency medicine physicians and teams. Further work is needed to study the impact of training and need for unit-level adaptation training.

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FIGURE LEGENDS

FIGURE 1. Team adaptive performance model

Letters are referenced in the text

FIGURE 2. Adaptive Learning System