Adapting Immersive Training Environments to Develop Squad Resilience Skills

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Abstract. The United States Army defines readiness and resilience as tactically proficient Soldiers and highly adaptive problem solvers capable of overcoming challenges and making decisions with strategic consequences in ambiguous situations. To address the resilience training gap, the Squad Overmatch study produced recommendations for employing immersive and live training strategies within the Stress Exposure Training (SET) framework. SET is a three-phase training method designed to provide information, skills training, and practice; with the goal of learning how to cope and perform while exposed to combat stressors. The potential for a wide range of Soldier experience levels in the pre-deployment training phase requires structuring and facilitating immersive and live training to develop resilience skills. In this paper we provide recommendations for adapting immersive environments to focus on assessing unit "readiness to train," and employing methods and tools that improve training effectiveness.

Keywords: Stress exposure training · Resilience · Immersive · Battlefield · Squad Overmatch

1 Introduction

Despite their extensive pre-deployment training and preparations, Warfighters must develop resilience on-the-job in an operational setting and struggle to manage the effects of emotional or operational stress as a result. Recognizing the need to overcome this problem, the US Army has been proactively addressing the challenge of improving Soldier performance, resilience, and readiness, and reducing vulnerability to Post-Traumatic Stress (PTS) through the Ready and Resilience Campaign – R2C [1]. R2C requires developing "tactically proficient soldiers and highly adaptive problem solvers capable of overcoming challenges and making decisions with strategic consequences in ambiguous situations." Preventative training for resilience is an R2C key priority; starting in the schoolhouse, and continuing through lifelong learning

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experiences. The Army Maneuver Center of Excellence (MCoE) has been aligned with this vision; their concept for Squad Overmatch (SOvM) focuses on making the Squad "the foundation of the decisive force." SOvM training requirements include developing the cognitive, physical, social-cultural, resilient, and moral-ethical components of the human dimension [2].

Solving the resilience training gap was the primary purpose of the Army Study Program's Squad Overmatch (SOvM) Study [3]. The demonstration was a paradigm shift from the current strategy of training warrior skills; an initial prototype was developed first so that Army squads could interact - "kick the tires" - and provide their evaluations of it. The Study was led by the US Army Program Executive Office for Simulation Training and Instrumentation (PEO STRI), and was a collaborative effort with several DOD agencies, including ARL HRED's STTC. The authors were part of the integrated product team leading the study evaluation, and contributed to the final report. The study report provides a detailed description of the evaluation findings and describes requirements for training methods, tools, strategies, and technologies that have the potential for improving individual and squad resilience skills. In this paper we summarize how the Stress Exposure Training (SET) framework was used to structure the SOvM demonstration. Lessons learned and recommendations are provided for increasing training effectiveness by adapting immersive environments, assessments, instruction, and feedback based on a soldier's "readiness to train."

1.1 SOvM Demonstration

Numerous guidelines have recommended SET for pre-deployment dismounted infantry combat training [4–7]. For example, Stanley and Jha recommended that training under more extreme conditions (e.g., injecting stressors such as battle sounds and smells) by exposing Warfighters to more complex tasks (such as having to concurrently manage treatment of casualties, communicate with locals, and provide security), may enhance Soldiers' resilience and performance after adequate physical and psychological preparation [7]. Sponsored by the Office of Naval Research, SET was developed as part of a comprehensive 10-year program of theory development and empirical research focused on improving tactical decision making under stress (TADMUS) in Navy combat teams [8]. The TADMUS program resulted in a detailed set of training requirements and guidelines for developing a "triad" of skills for resilience: decision making (DM), stress management (SM), and teamwork (TW).

The SET approach is counter to the notion that training under only extreme conditions hardens the Warfighter to combat stressors; an approach that neither improves resilience nor performance. It was designed for non-clinical settings as a framework so that instructional content could be adapted based on learning requirements for each of the resilience skills. The goal is for stressors to trigger employment of effective resilience skills instead of yielding to ineffective behaviors [9]. A 3-phase approach is employed that primes learning, sets learner expectations and then exposes learners and their teams to a series of progressively complex problems embedded with common stressors. Guided practice and performance feedback are critical to learning. In the second and third phases, practice takes place under graduated exposure to stressors in

simulations and live exercises, with the number and types of stressors gradually increased in successive training scenarios. Literature reviews and empirical studies have reported that self-confidence, stress management, and teamwork are improved with resilience skills training [4, 7, 10–12]. However, the complete 3-phase approach was never fully validated under the TADMUS program, and even today little is known about its effectiveness. Therefore, the SOvM study provided an opportunity to more fully vet the SET concept for operational training environments. Figure 1 depicts the concept of operation for the SOvM demonstration that is based on the SET design guidelines regarding stressor fidelity, training sequencing and content, training delivery, and assessments [9]. Training methods and technologies were selected for the evaluation that focused on DM, SM, and TW skills at the individual and squad level. A two-day demonstration was provided to each squad. Thirty-three Army soldiers participated as four separate squads. Level of soldier expertise ranged from zero to several deployments.

Information Provision. On the morning of day 1, soldiers were introduced to the SOvM concept. The evaluation strategy was explained, which was to provide their opinions on paper-based surveys and provide feedback through interviews following each capability demonstration. During the "Information Provision" phase soldiers were presented with a short instructor-led introduction to the Army's Training for Advanced Situation Awareness (ASA), the Comprehensive Soldier and Family Fitness (CSF2) program for stress management, and the Stress Resilience in Virtual Environments (STRIVE) prototype. A two-week training for ASA is delivered at the MCoE in an instructor-led classroom and through practical field exercises. The objective is to develop pattern recognition, predictive analysis and anticipatory thinking skills for high risk contexts [13].

The CSF2 program is an instructor led in-class course that is available twice during a 24-month training continuum (once during unit training and once during deployment) [14]. It provides cognitive skills training to build confidence, goal-setting, attention control, stress and energy management, visualization and imagery, problem solving, identifying strengths in self and others, and assertive communication. Participants learn that negative thoughts and emotions diminish task performance, and that replacing them with task-focused thoughts and positive emotions reduces stress. Behavioral modeling of appropriate behaviors and thought processes is used to introduce the trainee to how both thoughts and actions can influence stress reduction. STRIVE was developed by the Institute for Creative Technologies, University of Southern California, as an experiential learning prototype for developing stress management techniques and cognitive-behavioral emotional coping strategies [15]. It employs simulations and video-vignettes to present a set of combat scenarios that are part of a multi-episode interactive narrative experience. Users are immersed within challenging combat contexts and interact with virtual characters within these episodes. Videos employ avatars modeling appropriate coping skills behaviors.

Skills Acquisition. On the afternoon of day 1, for the "Skills Acquisition" phase, soldiers were introduced to STRIVE video snippets of typical combat stress scenarios and then had about an hour to play the gaming prototype Stress Resilience Training System (SRTS). Sponsored by DARPA and the US Navy, SRTS is a tablet-based game that collects noninvasive physiological measures for trainee biofeedback. It provides

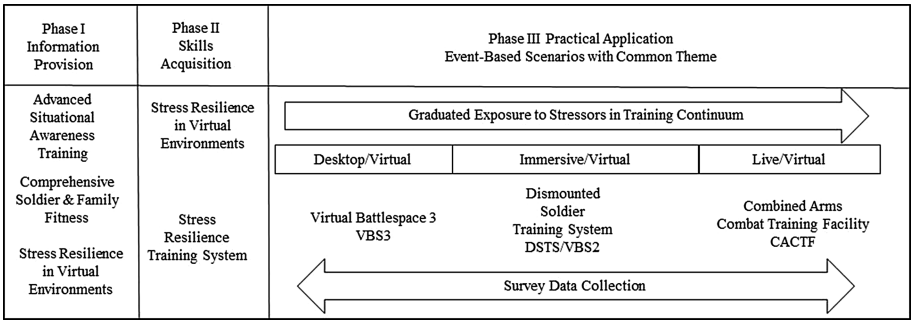

Fig. 1. Concept of operation for the SOVM stress exposure training demonstration

educational modules and games using the biofeedback data for learning cognitive restructuring and physiological stress management skills [16]. An automated Adaptive Coach monitors trainee progress and self-test results, and provides recommendations on how best to progress through the training program.

Practical Application. For the "Practical Application" phase, the study team used three mission task scenarios (Scenario 1 (S1), S2 and S3) in the context of an Eastern European theme; connecting the gaming, virtual, and live training environments with a common storyline. Following SRTS, squads interacted in the desktop Virtual Battlespace (Version 3) (VBS3) simulator and communicated over simulated radio nets to perform a squad mission in a village using S1 and S2 that were about 25 min each. VBS3 is an Army Program of Record (POR) that provides semi-immersive environments, dynamic terrain, simulated military and civilian entities, and a range of geo-typical (generic) and geo-specific virtual terrains [17]. The study team used the 3-D scenario editor to design and implement event-based scenarios with increasing levels of stressors.

The second day continued with "Practical Application" demonstrations; in the morning, squads participated in the Dismounted Soldier Training System (DSTS) virtual battlefield using S1 for about 25 min. Each Squad participated in an abbreviated planning session and then conducted a combat patrol. Then, for comparison, squads participated in a brief demonstration of DSTS with an enhanced graphics engine. DSTS is an Army POR that provides squad training that can support increasing levels of stressors using VBS (Version 2) [18]. DSTS provides a fully immersive 360-degree virtual view using head-mounted displays and un-tethered rifle simulators. Each DSTS standalone system is designed for an Army squad; it has nine un-tethered, manned modules, with an exercise control/After Action Review (AAR) workstation and one semi-automated forces workstation.

The last demonstration took place on the afternoon of Day 2. It was a combination of virtual and enhanced live simulations embedded at the outdoor Combined Arms Combat Training Facility (CACTF). Squads participated in the one hour S3 that demonstrated how embedding events with virtual targets, interactive dialog with multiple avatars, and enhanced realism (e.g., live role players and fake Improvised Explosive Devices) could be manipulated to increase stressors. CACTF is an

Army POR that provides a live environment for conducting individual Soldier-through-Battalion-level training in urban-operations at home-station [19]. Units train on building-entry/egress and room-clearing techniques under lethal and non-lethal operational conditions. The CACTF has an observer/controllers facility that monitors, controls and documents the training exercise with video recording for AAR.

Following the demonstration, soldier surveys were collected, analyzed, and a content analysis of interview transcripts was conducted with details reported in the SOvM study FY14 final report [3].

2 Lessons Learned and Recommendations

The SET framework afforded a flexible demonstration environment that allowed Soldiers to compare and contrast the desirability of each training capability. In this section, based on lessons learned, we more fully examine how a SET curriculum could be implemented and provide research recommendations in the context of each SET guideline.

2.1 Stressors, Coping Skills, and Fidelity

Conducting a thorough analysis of theory and empirically-based research, and working with Subject Matter Experts (SMEs) and known experts in the field helped to mitigate risk of problems with the final demonstration. Research literature reviews and interviews with SMEs led to identifying the key task stressors and cues that trigger performance problems in terms of psychomotor and cognitive processes. Walter Reed Army Institute for Research (WRAIR) scientists had thoroughly documented the combat stressors known to be related to PTSD [20]. The WRAIR scientists identified stressors and triggers in mission tasks involving searching, clearing, maneuver and engagement that increase risk of injury and death, including: clearing or searching homes or buildings, indirect fire attack from incoming artillery, rocket, or mortar fire, attack by enemy on forward operating base or patrol base perimeter, and engaging enemy with direct fire or returning fire, a close call, was shot or hit, but protective gear saved you; wounded in action, seeing ill or injured women or children whom you were unable to help, being responsible for the death of a noncombatant/enemy combatant, and exposure to human remains.

These findings, coupled with the TADMUS program results, enabled the study team to identify the three major squad coping skills – DM, SM, and TW skills - needed to mitigate mission stressors. Decision making (DM), involves establishing situation awareness (SA) through detecting, observing, and evaluating cues in the physical environment (including the human domain) that are needed to anticipate and effectively react to and make decisions about potential threats [21]. Teams develop shared SA of the common operating picture by passing key information and using proper communication protocols. SM skills involve using attention and concentration skills that manage and reduce distracting negative thoughts and physiological reactions experienced under stress [10]. TW skills help team members adapt to high stress and reduce

Table 1. SOvM case-based scenarios (DM=Decision Making; TW=Teamwork; SM=Stress Management).

Skill type	Event-based tasks	S0 Baseline	S1 Raid	S2 Financier	S3 Hostage
DM	Conduct tactical questioning			X	X
DM	Detain an individual		X		X
DM	Perceive threats		X	X	X
DM	Respond to contact		X	X	X
DM	Direct fire engagement		X		X
TW	Communicate information within squad	X	X	X	X
SM	Seeing ill or injured females or children		X	X	X
SM	Member of patrol wounded in action			X	X
SM	Exposed to dead bodies or human remains		X	X	X
SM	Responsible for death of a non-combatant			X	X
SM	Handle casualties		X	X	X

errors by exchanging critical information in a timely manner, providing priorities to focus DM, proactively monitoring each other for signs of stress, providing backup and support, and taking corrective actions without having to be asked [22].

Next, the study team adopted a previously tested case-based method to establish the link between the combat stressors and scenario triggers for resilience skills [23]. Scenario documentation established the traceability of event features in the storyline to requirements for DM, SM, and TW behaviors. Four case-based scenarios (S0, S1, S2, and S3) were connected through the Eastern European storyline. Table 1 denotes skill type, a sampling of event based tasks, and scenarios in which the tasks are triggered. S0 was designated a "low stress" scenario that was intended to allow the squads to practice establishing a "pattern of life baseline" for DM, but there was not enough time in the demonstration to use it. S1 (Raid), S2 (Financier) and S3 (Hostage) had increasing levels of embedded stressors. Events within each scenario that were expected to increase mental workload were interactions with the local populace, behavioral anomalies, communicating with own forces, and detecting deception by potential hostiles. Stress events were heavily weighted in S2 and S3. An objective of the study was to determine whether the tasks/stressor triggers were noticed by the squad members as an indication that the demonstration was successful in introducing them. Using an event-based scenario checklist, the authors found the soldiers reported or responded to many of the scenario events during the demonstrations with the VBS3, DSTS, and CACTF. Post demonstration most soldiers reported the events were realistic and relevant to developing resilience.

Recommendation 1. The study team learned that relevant stress triggers can be linked to DM, SM, and TW skill requirements and can be implemented in gaming, virtual and

live squad training. Research is needed to extend what was learned to determine how training each skill should be fully developed based on dismounted squad mission task requirements. Research should define and test specific skills for each phase of SET. Past research should be leveraged to solve this problem [8].

Recommendation 2. We learned that building scenarios to trigger resilience skills, and adapting the training environments for them was highly labor intensive; it took over six months to plan, design and author scenarios for the stress triggers in VBS3, DSTS, and CACTF. Nevertheless, the scenario development process using the case-based method is crucial to effective training because it sets the learning and performance objectives, and specifies expected performance outcomes for training assessment and AARs. Research should develop instructor training and support tools that automate the scenario design and implementation process to efficiently establish stressor fidelity for training simulations [12, 22].

2.2 Training Sequencing and Content

Recommendation 3. We learned that sequencing - information provision, skill acquisition and application - and training content are important for developing resilience skills. The ASA training and CSF2 curriculums demonstrated the potential to develop them within the SET framework. There was not enough time to introduce the squads to an example of a TW skills training (e.g., Team Dimensional Training), but the demonstration scenarios did include several TW tasks, and TW skills were discussed with Soldiers following each of the scenario runs with VBS3, DSTS, and CACTF.

Research is needed to develop and evaluate the complete curriculum for the information provision and skill acquisition phases, including how to encourage learning outside of class, and using valid learning measures for assessing and tracking progress and training transfer. We recommend that each resilience competency (DM, SM, and TW) have a separate curriculum, including the skills application phase. Scenario design should be used to create events that trigger learning within each competency. Following this, a simulation-based training curriculum with capstone exercises should help squads learn and practice skill integration. The training effectiveness of a complete curriculum for individuals and squads within a reasonable time frame in the pre-deployment training cycle needs to be determined. Research has shown that as little as one-hour of information provision training can significantly increase confidence in managing stress during a tactical scenario [10]. Similar results have been found with DM [8], and TW training [22]. Non-class time should be utilized, encouraging diary keeping, and providing on-line/mobile simulations and games for skill acquisition and practice. For example, research has shown that practicing cognitive coping skills and relaxation at least once per day outside of the training environment and preferably during typical stressful situations enables skills acquisition [9].

2.3 Delivery and Assessment

We observed that the wide range of soldier experience levels influenced the speed of demonstrations at each SET phase. Some Soldiers needed more time to understand the concepts than others. We also observed that squad leaders with more experience were able to help their squad members learn the concepts more quickly with examples and coaching behaviors. Part of the problem could have been solved if there had been more time available for familiarization with the new technologies. But, overall, we concluded that "readiness to train" should be a central factor to implementing SET. We propose that SET could be more effective if the Squad composition (i.e., training, qualifications, and experience levels) were better understood. Assessing Soldier competency and experience levels should be determined prior to implementing SET to tailor the curriculum depending on levels of proficiency. Five recommendations are discussed for adapting SET based on competence and experience levels.

Recommendation 4. Beginners are capable of observing instructors, avatars, or team leaders who model appropriate behaviors, but are not yet ready to acquire skills. SET should begin by focusing on acquiring knowledge, and learning principles and rules. At the intermediate skill level, soldiers can recognize critical cues in behaviors, and SET should move quickly to skill acquisition and application of job knowledge. At higher levels of proficiency, soldiers are able to perceive, think critically, and use adaptive reasoning and reflection, so SET should move quickly to the full application phase. Research is needed to develop measures that can support and evaluate an adaptive SET curriculum.

Recommendation 5. Research is needed to determine how types, not just levels of, stressors might influence Soldier expertise development. For example, the Center for Naval Analyses (CNA) developed a rationale for manipulating task stressors based on a model of expertise development in executing mission based tasks [24]. In a 10-year study of naval strike squadron live training, they developed a systematic method for assessing the development of pilot expertise from beginner (L1), through intermediate (L2) and proficient (L3), to highly expert (i.e., L4: instructor qualified). It involves gradually increasing the type and complexity, and stress, of conducting strike missions. For example, mission training should gradually increase complexity of skills training from "maintaining situation awareness" (L1), to "perform laser designation" (L2), "determine attack tactics" (L3), and then "assess go/no go criteria" (L4). An analytic method similar to the CNA study is needed for decomposing squad mission tasks into types of stressors, and documenting how it would impact developing squad leader expertise. For example, to address DM skills, beginners would focus on learning how to deal with information load and time pressure, whereas intermediate levels of expertise would focus on such stressors as uncertainty and risk management. Higher levels of soldier proficiency would focus on multi-tasking and in-stride planning. Research should apply this approach to developing squad leaders and squad skills within the context of platoon and company level missions.

Recommendation 6. The instructional strategy should be flexible, adapting depending on Soldier and squad expertise levels [25]. Beginners require more time on the orientation and familiarization of SET knowledge and concepts without stress exposure.

A more experienced squad should focus more on procedural knowledge with stress exposure supported by gaming environments, and then skills practice on mission tasks and procedures with stress exposure supported by a virtual simulation of a complex environment. A proficient squad should spend more time on deliberate practice in mission tasks and procedures supported by interaction with a live simulation of a complex environment. Research should focus on methods, tools, and strategies that support development of skills, and technologies that can recommend training to squads based on expertise.

Recommendation 7. The instructional system is the techniques, tools, and procedures that support the instructional strategy. This includes instructor and team leader roles. For the beginner level, a live instructor should spend more time on the information provision phase of SET, engaging trainees using a didactic approach, behavioral modeling, demonstrations, discussions, and out of class assignments using such games as SRTS. If squads have greater expertise, then they are capable of moving more quickly through the information provision phase to the skill acquisition phase. Trainees embedded in their squads should have instructors facilitating practical exercises, with application of job knowledge, and training systems that can provide automated assessment and feedback. At higher levels of proficiency, squads are likely to move through information and provision phases more quickly and can focus on planning and practicing problem solving exercises in distributed simulations. They can quickly develop skills in guided team self-correction, where the team leader engages the squad in their own AAR following simulation based training exercises [22].

We recommend that research is needed to develop an instructor/team leader training curriculum that would enable them to quickly adapt instruction based on level of soldier and squad expertise. It should include learning how to use assessment tools and such AAR methods as guided team self-correction. For example, a team leader prototype instruction was developed by Wilkinson, Holness, and Geisey and demonstrated with Soldiers and Marines [21]. Two instructional methods were adapted: the US Army's Think Like a Commander and the US Navy's Team Dimensional Training (TDT). They were revised to focus on the dismounted warrior and small unit team, and TLAC was renamed Think Like a Leader (TLAL). TLAL training was designed to train team leaders and their squads to: focus on the mission and higher's intent; model a thinking enemy/consider the terrain; use all available assets; see the big picture/visualize the battlefield; and consider contingencies/remain flexible.

TDT was designed for team leaders and their squads to use team self-correction to improve: information exchange; effective communication protocols; backup and error correction; and initiative/leadership. TLAL and TDT were linked together in the AAR and focused on empowering the squad to be proactive in the face of complex decision events. Key decision points were identified in each event-based training scenario and development of specific questioning probes were developed for use by the trainer and/or team leader in the AAR to facilitate self-assessment and reinforce the behavior themes in TLAL and TDT. The structured queries were developed before the AAR that link specific scenario decision events to the training to enable rapid post exercise development of the AAR and provide the trainer with clear, focused probes to ensure the discussion stays on track. The squad leader was trained on the process and was

provided the TDT/TLAL probes for his use during the AAR. The squad leader identified those areas of focus for the AAR, selected the TDT/TLAL probes to use, and rehearsed with the materials provided by the support team. The squad leader then conducted the AAR and employed the TDT/TLAL.

Recommendation 8. A main objective of SET is to ensure training effectiveness. Robust learning assessments and checks on learning throughout and beyond training are needed to transfer learning and reduce PTS. Achievement and knowledge tests support the beginner. Performance tests and feedback through AAR support the intermediate level trainee/squad. Team self-correction through AAR, reflection activities, and coaching feedback encourages transfer of what has been learned in the practical application phase. We recommend developing valid and reliable assessment tools that provide appropriate and immediate feedback to the trainees to enhance their coping skill strategies while they are exposed to the stressors. This helps trainees to adapt their behavior and responses in real time. Measures of trainee attitudes and performance to determine SET effects should be used; and multiple measures of performance and attitudes over time should be assessed. Measures of performance and attitudes should be assessed both prior to and after SET in order to determine changes in these factors. Research is needed to develop reliable and valid measures of learning, retention and skills transfer throughout the phases of SET.

3 Summary

Figure 2 translates our recommendations into a concept for adapting immersive training environments to develop squad resilience skills. Research is needed to evaluate this approach. We envision Phase I beginning with individual coursework, in and outside of class using mobile devices. DM, SM, and TW skills training would be implemented simultaneously, but as individual modules. During Phase II, individualized skills acquisition training continues with game-based training inside and outside of class. At the Practical Application phase, graduated exposure to stressors begins with individualized

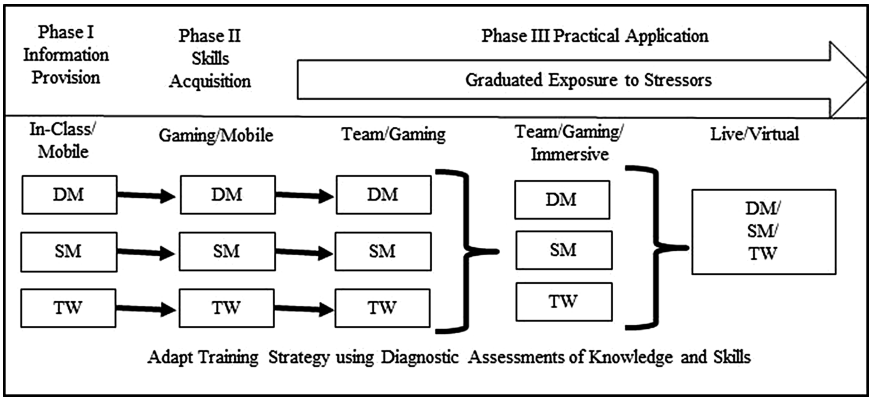

Fig. 2. A concept for adapting immersive training environments to develop Decision Making (DM), Stress Management (SM), and Teamwork (TW) skills for squad resilience.

skill training in a team-based environment. Next would be integrated skills training in gaming and immersive training environments. Capstone exercises with virtual simulations embedded in the live environment would enable team leaders and squads to demonstrate their overmatch capabilities. The training strategy would use diagnostic assessments of knowledge and skills to adapt instruction and training at each phase, enabling instructors and team leaders to tailor training based on level of expertise.

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