

Case-Based Next Generation Cognitive Training Solutions

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ABSTRACT

Transformational training solutions like the mixed reality Infantry Immersion Trainer (IIT) are being developed to demonstrate how to create an expeditionary mindset in small units. By framing the training experience to support a range of skills used to make novel and non-routine decisions under simulated conditions that produce stress, time pressure, uncertainty and high risk, the U.S. Marine Corps is transforming its approach to small unit training. The purpose of this paper is to report on applied research for creating training designs that address the shortfalls in the current systems approach to training. These limitations include the inability to rapidly generate training scenarios, lack of standardization in cognitive skills training, mistaking technology for training, and inadequate assessment and feedback tools. Each of these limitations affects training effectiveness. The Future Immersive Training Environment (FITE) was used to demonstrate how to overcome these limitations as part of a Joint Capabilities Technology Demonstration (JCTD), which was sponsored by the U. S. Joint Forces Command (USJFCOM). The key breakthrough was not the technology, though new training technologies were demonstrated. The revolutionary step was to create training designs to practice, develop, and assess small unit decision-making instead of trying to improve procedures and battle drills. The FITE JCTD was a first of kind decision skills trainer where small units could encounter non-routine tactical situations where they were required to make decisions and take actions that would shape their mental models. Case-based training was developed based on the results of cognitive task analysis, which produced a descriptive model of decision skills and their application against the insurgent planning cycle. A family of validated situational judgment test items was administered pre- and post-training to assess whether training had occurred and to capture what parts of the individual mental models had been encoded through effective training.

ABOUT THE AUTHORS

William A. Ross is a Principal Research Scientist at the Cognitive Performance Group, of Florida (CPG). His research interests include investigation into the nature and acquisition of cognition skills for tactical decision makers and the application of experiential learning to support the development and assessment of expertise. He is currently performing research involving the development and application of methods for mapping, assessing and influencing individual and group mental models within Irregular Warfare and Counterinsurgency (COIN) operational contexts. He is a cognitive scientist supporting the spiral development of the Future Immersive Training Environment, a prototype experiential augmented reality system for improving cognitive abilities within small tactical units.

Dr. David A. Kobus is the Director of Warfighter Performance at Pacific Science & Engineering Group, of San Diego, CA. He has been involved in human performance research and project management for over 25 years. He has served as the principal investigator, or as program manager, on over 30 research projects related to enhancing human performance. These studies have incorporated a wide variety of measurement techniques to assess human performance including behavioral, physiological, and cognitive psychophysiological techniques. He is currently involved in several projects related to the assessment of cognitive readiness of small unit decision makers. He has extensive teaching experience at both the graduate and undergraduate level and is a retired professor from San Diego State University. He holds an MS and PhD from Syracuse University.

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INTRODUCTION

The problem is quite simply stated. On the job training should not be primary method for training decision-making skills. We need to develop appropriate training content to allow small units to practice making decisions and act in novel and non-routine contexts to gain experience and develop suitable mental models for use in combat.

Current training solutions place value on repetition and procedures instead of practicing the cognitive skills that matter to the small unit leader. This situation is compounded due to the lack of training solutions available to learn how to make decisions and receive feedback on cognitive performance. The solution to cognitive skills training is about transforming how we design training cases and tools we must use to assess cognitive ability. Technology should not be mistaken for training; instructional or training technology is a tool. The recently completed Future Immersive Training Environment (FITE) Joint Capabilities Technology Demonstration (JCTD) was a tool box for constructing, sequencing, and assessing training, and there were many lessons learned (Ross, Becker, & Lindsey, 2011). The most significant was identifying how training designs need to be developed that enable small units to practice their cognitive performance within realistic contexts, where their mental models can be encoded with experiences that are readily transferrable to operational settings.

In this paper, we report on transformational training designs that support the Department of Defense Strategic Plan for Next Generation Training (Office of the Under Secretary of Defense Personnel and Readiness, 2010) by demonstrating rapid scenario generation, best practices for cognitive training solutions, and an approach that delivers meaningful feedback about individual cognitive performance. The goal of transformational training designs is to contribute to the development of resilient small units who are capable of succeeding in full spectrum operations. In order to achieve this goal, the research applied Cognitive Task Analysis (CTA) methods to

represent individual mental models of decision demands and used these representations to construct descriptive model of the cognitive abilities that infantry squad members must master and use when conducting combat patrols. The CTA results influenced the technology development, operating conditions, and assessment strategies, which reinforced learning (Crandall, Klein, & Hoffman, 2006; Militello & Hutton, 1998). This paper describes the design and use of cognitively authentic, case-based training to prepare small units for missions in complex, adaptive environments. More significantly, the use of applied research combined with decision critiques and situational judgment tests to unmask newly encoded mental models used to decide and act in novel situations. The measurement of cognitive abilities based on mixed reality experiential learning provided diagnostic feedback as well as guidance for trainers on how to improve perspective taking, pattern recognition, empathy, and resilience under significant cognitive loads. This research produced empirical evidence of the impact of training and use of decision critiques on small unit cognitive readiness.

Cognitive Task Analysis and the Mental Model

Lived-experiences and tacit knowledge which are used to train decision skills are pivotal for framing cognitive training solutions (Ross, Kobus, & Phillips, 2011). From the outset, we realized that these inputs must be reflected in what was trained and measured irrespective of the training technology. We proposed a training design that was framed by our understanding of the operational context. The goal was to encode individual mental models by immersing the learners or training audience in a cognitively authentic training context.

Narratives of critical incidents were collected by interviewing small unit members who had at least one deployment experience that included combat patrols. Verbal protocols were prepared and used to conduct interviews with Marines and Soldiers, who then described what they sensed, what they knew and where they were challenged during a typical combat patrol. The accounts of their experiences were transcribed,

coded, and analyzed. The findings were presented as set of decision demand tables which were cross-tabbed and indexed to ensure traceability to the source. Concept saturation, reviews by subject matter experts (SMEs), and follow-up with the participants were employed to validate the content of the demand tables and to review the structure of the descriptive model of dismantled infantry operations which we developed.

The descriptive model provided a framework that showed the cognitive abilities and job skills that were used to conduct a combat patrol. The model is illustrated in Figure 1.

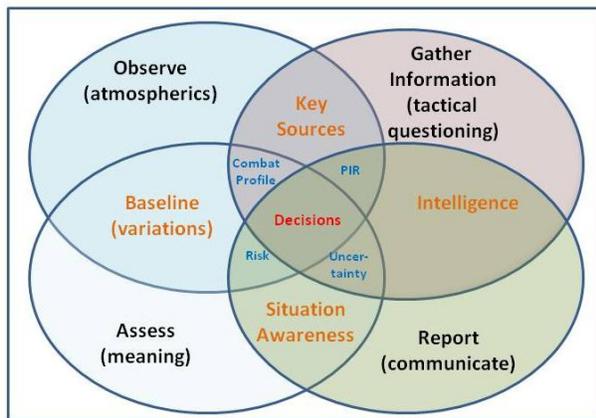


Figure 1. Decision Performance Indicated by a Combination of Factors and Abilities

Four abilities were described: (1) Observe, (2) Collect, (3) Assess, and (4) Report, which correspond to the “OODA (Observe, Orient, Decide, and Act) Loop” described by John Boyd (1996, January). The interaction of these abilities provided indicators of squad’s performance that could be measured and verified during training. The indicators included the accuracy and currency of the baseline, recognition of reliable information sources, the development and exploitation of actionable intelligence products and maintaining situational awareness across the squad and within the platoon.

OVERCOMING LIMITATIONS IN CURRENT TRAINING SOLUTIONS

Repetition and procedural training help to create automaticity and conformance to doctrine. They are not the optimal design for promoting adaptive thinking or resilient small units that are capable of managing decision complexity or dealing with novel or non-routine problem contexts. We used a decision-centered

design approach to generate transformational training designs.

Scenario Design Process

The results of the CTA provided the content for the training cases. The purpose of the design process was to define a set of specifications that would yield a training experience for encoding individual mental models and testing to verify how the mental models had changed.

The design process consisted of three stages: (1) Framing, (2) Validation, and (3) Demonstration. Each of these stages resulted in design artifacts which were used by training developers to configure and instrument the mixed reality training platform.

Limitation 1. Lack of a Rapid Scenario Generation Tool

Scenario generation is problematic because there are several simultaneous users and their information requirements vary. Initially, we believed that we were only supporting the simulation developer. Instead we found that the users included trainers, controllers, technologists, and evaluators. We extended our definition of process outcomes to ensure each consumer had what was needed to accomplish his portion of the JCTD. The scenario design products were the specification that unified the project team’s efforts.

Total process time was about eight days to produce a design specification that was ready for validation. Small unit training requirements and CTA results were the primary inputs to the process. Case-based training solutions included a narrative description of the event, which identified the types of dilemmas that the squad was likely to encounter as well as the tactical tasks which were supported.

Limitation 2. Lack of Standardization

The best practices that support the design of standard training scenarios do not exist. Considerable effort was devoted to prescribing a process and a standard set of deliverables to inform training development. This lack of standard solutions yields levels of variation that interfere with the delivery of effective training and assessment.

To address this problem, the design team established and used a cognitive systems engineering methodology to generate its designs. We developed use case diagrams and used them as templates to guide the

execution of training solutions. A use case in this sense is a graphical representation of the functionality used by the squad to resolve a tactical dilemma. It served to promote common grounding and create a single performance focus among the developers, trainers and controller staffs.

Limitation 3. Mistaking Technology for Training

Training dismounted infantry patrol is not a glamorous activity. It is dirty, noisy, and calamitous if it is to be realistic training that requires leader involvement. Small unit leaders participated in all aspects of the training process. Training was to standards and under conditions prescribed in the Infantry and the Operational Culture Training and Readiness manuals (U.S. Department of the Navy, 2005, September; U.S. Department of the Navy, 2008, April).

The FITE JCTD was a one-of-a-kind examination of cognitive training concepts. These concepts required a suite of integrated training technologies such as intelligent avatars, natural language interfaces, animatronics, instrumentation and replay capabilities be on-line to generate the degree of realism required to demonstrate proof of concept. The primary challenge was the integration of each technical capability into a single training platform. This integration challenge was exacerbated by technology readiness levels of some of the systems. Like most projects that mix training and advanced technologies, a preponderance of resources and management attention was devoted to ensuring the technological solutions could be demonstrated.

Limitation 4. Inadequate Assessment and Feedback Tools

The measurement and assessment of cognitive performance is confounded when conducted as part of an open system. There were no scripted events or scenarios used during the FITE JCTD. Each squad determined the sequence of their actions and decisions within the structure of the training case. And while there was ample instrumentation capable of tracking every moment in the life the squad members, the instrumentation could not look into the mind of the decision maker to determine cause and effect relationships with certainty.

Three assessment approaches were introduced during the FITE JCTD to overcome this limitation: (1) Team Dimensional Training, (2) Decision-centered After Action Reviews (AARs), and (3) Situational Judgment Tests (SJTs). Figure 2 describes the overall roadmap

for a continuous improvement of decision and tactical skills based on the squad's performance.

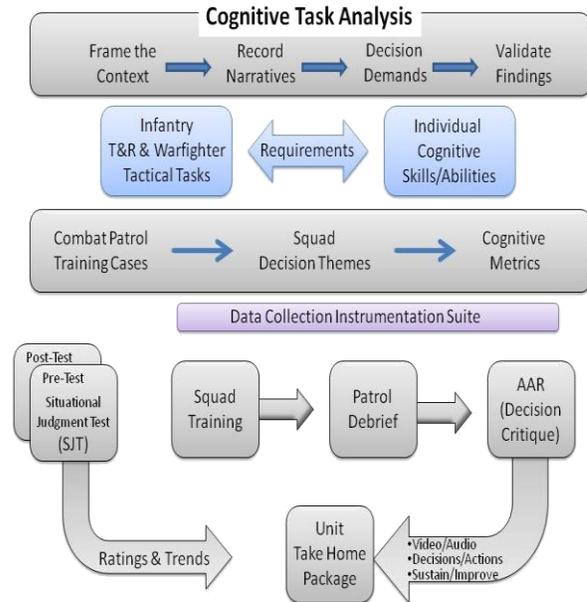


Figure 2. Scenario Design Grounded in Tactical Tasks and Decision Skill Requirements

As part of their orientation, each 13-member squad that made up the training audience received instruction on the team building, collaboration and communication by trained facilitators. Team Dimensional Training provides a framework for managing internal process performance and ensuring that outcomes contribute to mission success. Its goal is to create the foundation of a high performing team. It is not itself decision skills training.

Following the patrol debrief to the company-level intelligence cell (CLIC), the squad members participated in an AAR. These AARs emphasized team problem solving. Decision-centered AARs shifted the focus of the discussion from tactics to decision-making. We trained AAR facilitators on an approach for AARs that required the squad members to review key decisions as a way of understanding how and why decisions are made within the squad. The goal was to create or update a shared mental model within the squad of a complex decision event that could be carried forward to operational contexts. At the conclusion of each training run, the squad participated in a decision-centered AAR.

The final assessment strategy was completion of the SJT. The items on the SJT consisted of a short vignette presenting an operational dilemma, five plausible potential courses of action, and rating scales to rate

their perceived effectiveness for each action meeting the needs of the dilemma. The trainee reads or listens to each vignette and then is given time to rate each course of action. Each vignette represents a similar dilemma to those reflected in the training. Trainees completed two SJTs based upon the same decision dilemmas. Ratings were collected before training began and after the final training event. The pre- and post-training ratings were evaluated to determine training effectiveness upon each of the decision themes and to assess whether the individual learner scores approached those of the SMEs who validated the items.

MAKING SENSE OF THE RESULTS

The FITE JCTD was conducted as a series of technical and operational demonstrations. As part of each demonstration, either Army or Marine squads took part and conducted training. The integrated technology was used to demonstrate virtual and mixed reality training platforms; the real payoff was in the quality of decision skills training.

Only Marine infantry squads participated in the mixed reality operational demonstrations. The training consisted of combat patrol training that interacted with civilians, host nation security forces, a platoon headquarters and virtual adjacent squads. The full training continuum consisted of five security patrols that were conducted over a three-day period.

A Typical Training Event

No two patrols were alike and no sequence of events was repeated. The squad encountered a series of dilemmas or decision events based on their individual plans and their reactions to events that made up the Master Sequence of Events List (MSEL). There was a MSEL and use case for each scenario, which described the conditions and potential trigger events that were most probable.

Training consisted of five inter-dependent dismounted security patrols conducted on complex, urban terrain that included distinct cultural components. The training began with a patrol brief and intelligence update. This was followed by troop leading procedures to ensure that the squad had prepared for and mentally simulated its actions and task requirements. Following a short period to “gear up”, the squad entered the mixed reality simulation to conduct its patrol. The squad interacted with their environment in their own way and responded to cues or dilemmas as they were presented. Once the patrol was completed, generally after 45-50 minutes in the simulation, they conducted a

patrol debrief where they reported what happened, updated their situation awareness, and identified next steps for future patrols. Once the debrief was completed, the squad met with the Facilitator or Trainer (normally the Platoon Commander) to conduct an AAR. The AAR was supported by information from the instrumentation suite, which was cued to collect performance data related to specific decision themes. This was done by identifying the decision triggers so that the audio and visual systems were oriented throughout a training scenario. The Trainer was also able to monitor the patrol and tag video segments or audio data that he wanted to replay during the AAR.

Situational Judgment Test Results

We incorporated the SJT findings with the assessment methodology and used the results to characterize the training outcomes (Kobus, Kobus, Ostertag, Kelly, & Palmer, 2010). The SJT items were constructed based on 27 of the decision themes that were used to construct the training cases. For each theme, we constructed two vignettes with associated courses of action (COAs). As illustrated in Figure 3, we used multiple stages of validation.

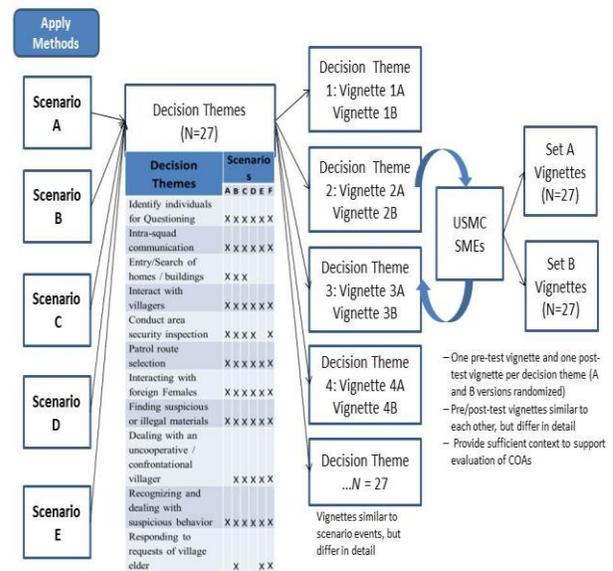


Figure 3. The SJT Development Process Used to Generate and Validate Test Items

Experienced Marine trainers verified the content of each vignette and associated COA. Once content validity was established, we used another group of highly experienced Marines to assess the individual COAs and assign a rating score, 1 – 5 based upon the

effectiveness of the action to address the concern identified in the vignette. In this manner, we constructed a SME database (baseline) that could be used for comparison with trainee scores. The end state was a set of validated items, which we used to construct parallel forms of the SJT instrument. Trainees as well as control group rated both versions of the SJTs. The control group displayed no significant difference between their pre-versus post-test ratings.

We administered the pre-test version before the training squads received any Infantry Immersion Trainer (IIT) guidance. The control group was treated in a similar manner, but did not receive training. After the training was completed, approximately three days, both the training squad and the control group were administered Form B of the SJTs. Then their ratings were analyzed. The analysis approach is illustrated in Figure 4. The data analysis allowed us to assess whether training had taken place and what decision themes resulted in new encoding for individual mental models.

The first stage of analysis confirmed that our performance model was adequate. Using root mean square analysis of the two sets of score, we identified significant differences and clustering around the two means. The next stage was used to compare pre- and post-training scores. In this stage we analyzed scores using the pair-wise t-test to determine whether training had taken place. The results identified in the decision themes suggested these changes were significant. Percent of decision themes showing improvement per

individual ranged from 26% (squad leader) to 85% (riflesman).

Differences between squads led to further analyses of the squad results independently. Due to the smaller sample size, a different measure (Krippendorff's alpha) was used to assess the level of agreement between squads and SMEs across all five responses for each decision theme. Difference scores were computed for each vignette and individual t-test values were then calculated to determine statistical significance.

This analysis shows that the mental models of the training squads have been affected by the training, promoting the decision-making, post-training to be more like SME's. We conclude from this analysis that the mixed reality immersive training resulted in significant gains in cognitive abilities as well as changes in the mental models for those who participated. We also found that specific theme items that were reviewed and discussed during the AAR, in general, demonstrated greater improvement.

WHY WAS THIS TRANSFORMATIONAL

The unit of action for the FITE JCTD was the dismounted infantry Marine or Soldier. The unit analysis was the individual mental model. The goal of transformation is to shift the mindset of each Warfighter to full spectrum operations through organizational learning, new organizations, and the development of cognitive abilities across the force.

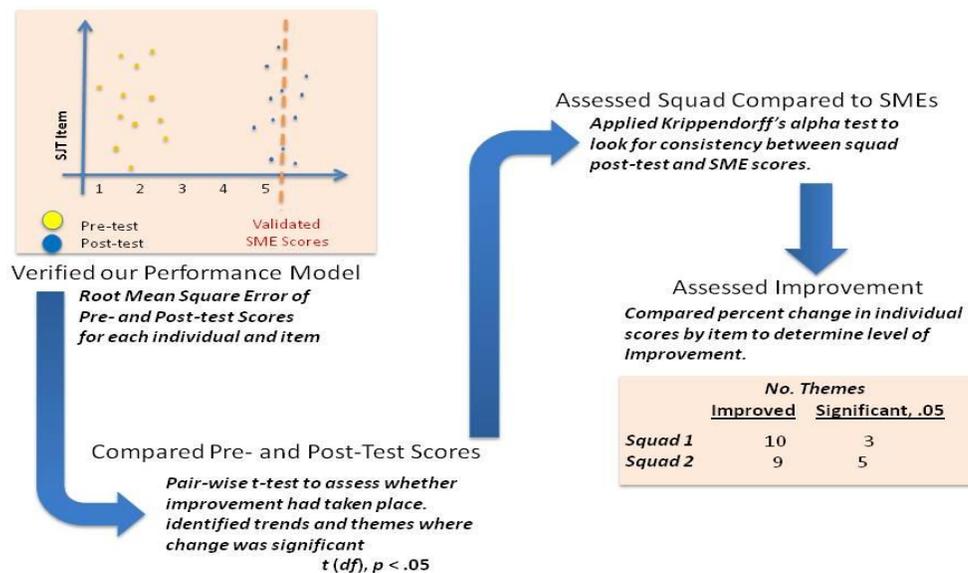


Figure 4. The SJT Analysis Process

The entire training solution was decision-centered, and not technology driven. The scenario designs were framed by decision demands. The instrumentation was cued to collect information about the decisive events in the training cases. The AARs and the SJT also leveraged decision themes.

While the training technologies and instrumentation suites were state-of-the-art, they did not account for the training outcomes. More likely, we believe that cognitive authenticity in the scenarios as well as in the mixed reality training facility were essential. We were able to introduce time pressure, multi-tasking and in-stride planning requirements to place higher cognitive demands on the training audience. When the mixed reality, IIT was used to practice decision-making and was part of the critique during the AAR, teams displayed marked improvement in their decision-making.

FUTURE RESEARCH

This research lies at the threshold of small unit decision-making and the need to revamp how we identify the cognitive requirements and develop the cognitive abilities in young leaders who must demonstrate resilience and adaptability in future conflicts. The design of training around decision requirements that can be linked to training and readiness is another next step. To achieve full acceptance, cognitive training solutions must be clearly linked to operational performance. Tools for creating case-based cognitive training solutions for the Infantry platoon are also necessary. Finally, assessment methods, like SJTs and decision critiques that incorporate constructive feedback about cognitive skills and abilities, are needed and should become best practices. Research to capture these practices and standardize them for today's Warfighters is needed.

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