Improving Company Commander's Visualization in Irregular Warfare

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ABSTRACT

A commander's ability to visualize how to move the force to the desired end state is especially critical in irregular warfare. Current training on commander's visualization, however, is limited and lacks effective methods for developing expert visualization skills. Expertise is best attained by integrating education, training, and experience with deliberate reflection and practice. To improve commander's visualization in irregular warfare, the U.S. Army Research Institute for the Behavioral and Social Sciences (ARI) developed and assessed an educational product called *End State: Commander's Visualization at the Company Level*. A separate version of *End State* for battalion commanders was also developed (Shadrick, et al., 2008). The company-level research reported here features innovative methods to advance learning and empirical data for assessing and understanding novice versus expert differences in commander's visualization.

End State for company commanders is a multi-media educational and assessment product that includes 14 learning modules, a pre-test, and a post-test in a sequential series of scenario-based vignettes situated in Iraq. Learning begins with "reflection" vignettes in which learners observe and reflect on the exemplar performance of 3-D animated role models. Learning progresses to complementary "action" vignettes where learners apply their visualization skills and receive immediate, instructorless feedback and assessment. The paper reports results from a formative evaluation with 48 captains and lieutenants that guided product refinements and concluded that *End State* is effective, relevant, and worth using. The paper also reports results on research conducted to ensure parallel pre- and post-tests for *End State* and develop normative standards of novice versus expert performance on commander's visualization. The results establish a needed empirical base to understand and improve commanders' ability to visualize irregular warfare.

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INTRODUCTION

"Where there is no vision, the people perish."

Success in military operations depends on the ability of commanders to visualize an increasingly complex and irregular operational environment. Commanders must make sense of a world that is often warped "senseless" by threat forces intent on disorder and chaos. In sum, the nature of today's dynamic and "counterintuitive" warfare underscores the need for training to improve commander's visualization, to instill the proactive ability to visualize and shape irregular operations.

To help commanders visualize irregular warfare, the U.S. Army Research Institute (ARI) initiated a multi-year research program to train commander's visualization at company and battalion levels. As a result, ARI developed two complementary products called *End State* that feature deliberate practice in irregular warfare scenarios with expert guidance and feedback to improve commander's visualization. The company and battalion products share an integrated design that includes nested scenarios set in Iraq with a common Road to War and Rules of Engagement (Shadrick, Leedom, Bell, Manning, Lickteig, 2008). This paper focuses on the company–level product called *End State -- Commander's Visualization at the Company Level*.

This paper reports on three incremental evaluations to develop and validate the company version of *End State*: a cognitive task analysis (CTA) that examined the visualization challenges and requirements in irregular warfare; a formative evaluation that reviewed and refined the design of *End State;* and, experimental research to develop and validate parallel pre- and post-tests in *End State* to assess training effectiveness and develop normative standards of visualization.

The paper begins with a short review of doctrinal guidance on commander's visualization through consideration of task, purpose, and challenges. Next, the paper documents some of the basic visualization challenges and principles unique to irregular warfare identified by CTA participants during evaluation one. Based on results from the CTA, the paper then briefly describes the design and development of the *End State* product formatively assessed during evaluation two. Next, key results from the formative evaluation are reported, including product refinements recommended by 48 officer participants and revisions made to *End State* based on their recommendations. The paper then reports evaluation three efforts to develop the parallel pre- and post-tests needed to assess *End State*'s training effectiveness and develop normative standards of novice versus expert performance in visualizing irregular warfare.

Commander's Visualization

Vision's value in military endeavors is aptly conveyed by Proverbs (29:18): "Where there is no vision, the people perish." The ability of the commander to visualize operations is considered a guiding and indispensable force in regular as well as irregular warfare and a cornerstone of commander's expertise.

Visualization is the ability to think and create in mental images and processes that may extend into the past and future, including dynamic and complex images not physically present. To visualize operations, commanders must develop situational understanding and envision how to move the force from its current state to the desired end state. Visualization is a higher-order skill that transcends, for example, the relatively narrow "volume of time" associated with a related construct called situational awareness (Endsley & Garland, 2000). As shown in Figure 1, commander's visualization of military operations spans time from

"Where we are now" to "Where we want to be" in order to accomplish the mission. Visualization is the process by which commanders (DA, 2003):

- Develop a clear understanding of the current state.
- Envision a desired end state that represents mission accomplished.
- Determine a sequence of activity to achieve the end state.

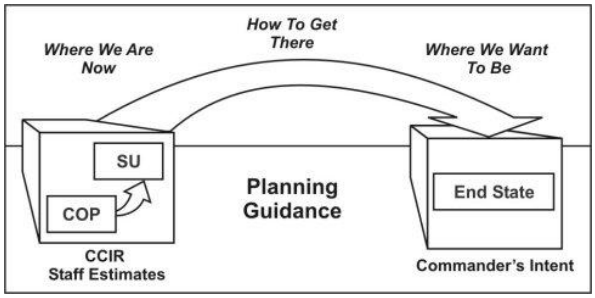

Figure 1. Visualize throughout operations

Army doctrine and command practice assert that the commander's vision is framed by the factors of Mission, Enemy, Terrain, Troops, Time and Civilians (METT-TC). Commanders also draw on the principles of war, the tenets of Army operations, and particularly their own experience and judgment to form an understanding of the situation and to visualize the operations required.

Commander's visualization is a continuous process which begins in planning and repeatedly updates until the force accomplishes its mission. Visualization is the commander's essential means of assessing and adjusting operations. By continually confirming or modifying his vision, the commander determines when and where to make a decision, as well as what decisions are needed (DA, 2003).

On a more personal level, the commander's vision leads and motivates the force. It convinces Soldiers their commander sees and understands the mission, the enemy, and the situation in a manner that strengthens and secures their course of action toward the end state.

As the commander's visualization forms and evolves throughout an operation, it is frequently described and shared to revise how ongoing actions and resources must be directed to accomplish the mission. Doctrinal methods for describing the commander's vision to others, include: commander's intent, planning guidance, and commander's critical information requirements (CCIR). It is the process of sharing and shaping visualizations that links collective thought to collective action.

Visualization Challenges

Caveats abound on the many potential problems in forming and communicating the commanders' visualization (DA, 2003). Commanders base their visualizations not only on facts, but also on their interpretation of them; not only on their observations, but also on the observations and interpretations of others. Invariably, the higher the commander's level, the more removed the commander is from the situation, from direct observation.

A related problem is that while high-technology information displays extend the commander's vision far beyond line-of-sight, the information and images displayed may appear more reliable and timely than they are (Wallace, 2005). As the amount of information expands, and the time to process it contracts, reports tend to lack significant details or contain hasty errors. The process of sharing information and visualizations adds more distortion and delay across the many persons, nodes, and echelons required for collective enterprise.

In myriad ways commanders must counter these and many additional problems in visualizing operations. In particular, expert commanders base their decisions on information from as many sources as possible. They exploit all available assets to proactively gather the information and intelligence needed to best determine what the enemy will do, when and where. However, despite all resources available, commanders must rely ultimately on their *own* visualization. Only the commander makes the decisive "read" through fog and friction that commits the force toward peril and the end state (Wallace, 2000).

More recent doctrinal literature cogently stresses the unpredictable and intentionally disordered nature of irregular warfare. The recent counterinsurgency field manual (DA, 2007) describes the current operational environment as counterintuitive in settings such as Operation Iraqi Freedom (OIF) or Operation Enduring Freedom (OEF). Typical areas of operation (AOs) are riddled with paradoxes that contradict many of the familiar patterns and principles commanders have traditionally used to visualize operations. Examples of the paradoxes cited, and briefly paraphrased here, are:

- Force Protection = Less Secure
- More Force = Less Effect
- More Success = More Risk
- Often Doing Nothing = Best Action
- Often Best Weapon = Don't Shoot
- What Works Today ≠ Works Tomorrow
- What Works Here ≠ Works There

Training Requirement

The commander's ability to visualize is a human performance requirement. It is attained through education, training, practice, experience, and aided by battle-command tools and technologies (DA, 2003). Technology may help, such as the U.S. Army's investment in network-enabled battle command systems, but it is not the answer.

Unfortunately, current methods for training visualization skills are not sufficient. Too often "training" equates to placing commanders in a realistic situation and hoping they "figure it out." Yet, research on the development of expertise clearly indicates that "train as you fight" immersion in fully simulated and realistic battles is neither the most effective nor efficient method of developing expertise (Ericson. 1996). In most domains, expertise is not a happenstance; not the result of incidental or discovery learning. The development of expertise generally requires highly structured and focused learning methods that progressively mold and hone performance to match expert models.

Moreover, institutional training is quickly outdated when students return from deployments with more relevant knowledge than instructors. Meanwhile, challenges to training visualization only worsen due to: unpredictable threats, a multitude of interagency and multinational considerations, an endless stream of technology insertions that result in more complicated and networked systems, and increased "turbulence" in personnel, organization, and doctrine.

EVALUATION ONE: COGNITIVE TASK ANALYSIS

To understand how expert or more experienced commanders visualize small unit, company/platoon, operations, ARI conducted two complementary CTAs on the visualization challenges and skills required for irregular warfare.

CTA One

The initial CTA began with a literature review of doctrinal and professional publications related to small unit visualization. Lessons distilled from the literature were then used to develop and conduct a series of scenario-based workshops on visualization with captains and lieutenants, as reported by Sidman and Garrity (2007).

Method

The workshop participants were 48 active duty captains and lieutenants that were assigned to small groups of 5-6 participants per workshop at Forts Hood, Knox, and Lewis. Each workshop was structured as scenario-based exercises situated in Tikrit, Iraq to examine participants' visualization requirements in the conduct of re-current small-unit missions. In advance, the research team developed five representative small-unit missions such as React to an Improvised Explosive Device (IED) and Cordon and Search. An orientation brief by a military subject matter expert from the research team explained the workshop's focus on commander's visualization and pre-viewed the five missions available for the group's workshop effort. All workshops were recorded and observed by a 4-5 person research team.

Each group then selected the one mission (or two, if time allowed) that the group was most familiar with during their deployments. After the group planned a course of action (COA) for their selected mission (see Figure 2), the leader of the group briefed the course of action back to the members of the research team. Debriefs by the research team inquired about the challenges and requirements encountered in visualizing the group's COA. More specifically, what were the key environmental cues and considerations used, and the information and techniques required, for the group's planning and decision making?

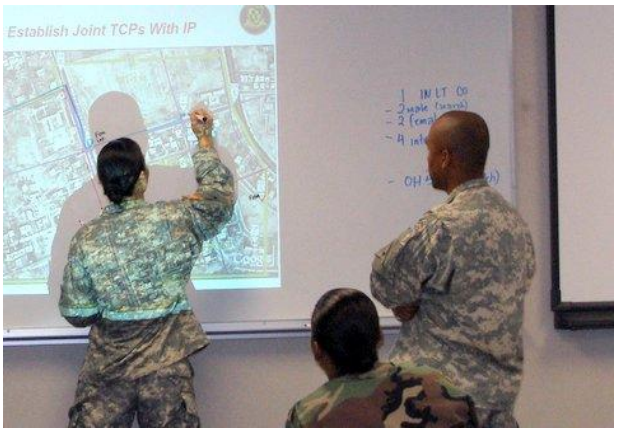

Figure 2. Participants planning course of action.

Results

Initially, workshop data for the five vignettes including the participants' COAs were analyzed to identify standard phases of time and space across small unit missions. Though the scenarios differed significantly, the analysis identified common phases, techniques, and procedures used to acquire the knowledge needed to visualize time-space interactions. Five common phases were identified across scenarios, and examples for the first two of the five phases are provided below:

Pre-Mission Prep: Conduct Pre-Combat Checks (PCC) and Pre-Combat Inspections (PCI); rehearse missions with Iraqi units; use patrols to rehearse missions; talk to Battle Captains.
Move from FOB to Objective: Select ingress routes; determine the goal of the movement (speed versus risk); determine order of movement; identify paved roads; consider time of day.

The CTA also identified task-independent versus task-dependent (Serfaty, 1997) visualization requirements and considered their implications for training transfer. The analysis focused on identifying task-independent principles for visualizing small unit operations that would generalize across AOs. Overall, the analysis identified four basic principles that stress the speed and complexity of visualizing irregular warfare in urban operations:

Time is compressed in the AO. Events occur quickly and unpredictably often forcing Army units into a reactive mode.
Space is compressed in the AO. Urban environments are dense areas of multi-dimensional buildings, narrow alleys, and road intersections full of blind spots and obstacles that restrict observation, maneuver, action, and coordination.
Humans further compress the AO. Humans are the key "terrain" in urban settings and their presence often creates obstacles, cover, and concealment that greatly complicate visualizing operations.
Know your AO. Expert commanders learn to visualize operations by developing an ingrained knowledge of their AO. Knowing and understanding their AO's time, space and human terrain factors, allows expert commanders to shift their visualizations of an operation and their unit's actions from reactive to proactive mode.

Next, the CTA identified an extensive set of knowledge requirements to "Know Your AO" such as the need to know and understand vehicle and human traffic, tribal and political boundaries, and culturally sacred and off-limit structures. Corresponding techniques to acquire the knowledge required were compiled from the workshop data, such as these techniques for knowing about IED attacks:

- Develop a clear understanding of the current state
- Study mission packets at home station
- Attend all INTEL and Situation briefs
- Collect and review historical pattern analyses related to IED attacks
- Receive and deliver Right Seat Rides
- Maintain vigilance on "routine" patrols -- "Be the hard target!"
- Engage the local people frequently to collect information – "The people know the AO."

From a training perspective, participants strongly affirmed the need for better training on time and space dynamics in their AO. Only a few examples of schoolhouse visualization training were cited including "what-if" exercises to help Soldiers consider contingencies for unexpected events. Another was "what's missing" exercises that removed objects from a room or an area and then tested Soldiers on what's different. Many participants stated such exercises made them more aware of changes in their environment.

CTA Two

A follow-up CTA was conducted to more directly relate a commander's visualization skills to subsequent decision-making and action, and also to identify a skill framework for visualization compatible with the rapid tempo of company and below operations. CTA 2 began with a series of structured interviews with recently deployed small unit leaders and then the interview findings were integrated with CTA 1 results and with further reviews of the military literature.

Method
A series of structured interviews were conducted with 18 officers enrolled in the Maneuver Captains' Career Course, Reserve Component (MC3 RC) at Fort Knox. The participants were, with one exception, all captains and lieutenants with command experience at company and platoon levels during recent OIF/OEF deployment. Participants reviewed the visualization principles and techniques from CTA 1 and related their training and operational challenges in commander's visualization.

Results
The interviews confirmed the rapid tempo of small unit operations in irregular warfare. Participants stressed that efforts to visualize operations were complicated by urban pace and density and by the difficulty of identifying threats concealed in unfamiliar human terrain.

Responding fast enough was almost always a challenge; responding quickly and correctly was a far greater challenge. A key finding from the interviews was the need for proactive thought and action. Unfortunately, the unpredictable and disordered nature of irregular warfare too often forces small unit commanders and forces to be reactive (Hammes, 2004). The interviews underscored the need for new training methods to conduct irregular warfare, to render order from disorder and even chaos.

The CTA 2 literature review reinforced the interview findings. In a notable example, Kurtz and Snowden (2003) relate a case in which a group of Marines went to the New York Mercantile Exchange and competed against professional traders in a simulated trading environment. Of course, the traders always won. But when the traders visited Quantico and competed in simulated war games against the Marines, they won again. One interpretation is that traders were skilled at spotting and shaping patterns, while Marines were trained to collect and analyze data in order to make rational decisions for an orderly world. Similarly, Hammes (2004) provides telling guidance on the conduct of irregular warfare:

"*Fighting an asymmetric enemy successfully in complex environments is less dependent on reacting to the enemy than it is conceiving viable options that cause the enemy to react*." (p. 2).

CTA 2 also focused on identifying a skill framework for visualization compatible with small unit operations. The most proactive model identified was the Observe-Orient-Decide-Act (OODA) Cycle (Boyd, 1987). A depiction of the OODA cycle from Field Manual 6.0 (DA, 2003) is shown in Figure 3 which illustrates the iterative sequence of thought and action as commanders:

- **Observe** the situation to collect information
- **Orient** by developing situational understanding
- **Decide** what to do and how to do it
- **Act;** then observe threat reaction to restart OODA

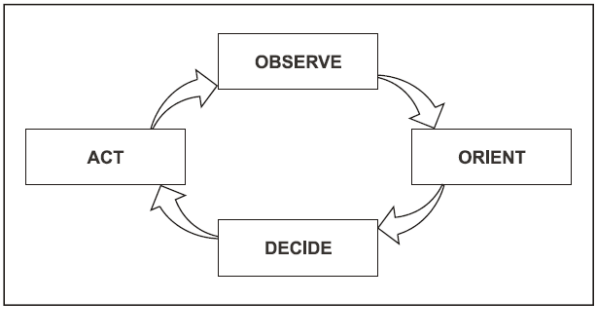

Figure 3. OODA cycle from FM 6-0 (DA, 2003)

Ultimately, the OODA cycle was selected as the skill framework for visualizing small unit operations in the *End State* training product. Overall, the OODA cycle seems to afford a powerful combination of basic and higher-order training effects, as identified in Table 1

These training effects are considered the product's desired end state for commander's visualization and, in turn, guided all phases of the design, development, and refinement of *End State*.

Table 1
Training Effects Anticipated from an OODA Design

Basic Effects	*Higher-Order Effects*
Provides proactive model	Integrates across players
Reflects small-unit tempo	Focuses interdependent visions
Links thought to action	Underscores ripple effects
Keeps training simple	Provides end-to-end guidance
Scaffolds skill building	Coordinates action cycles

The OODA cycle reflects the rapid tempo of small units that must quickly relate thought to action. It is a proactive model focused on getting inside the Enemy's decision loops that provides commanders end-to-end guidance throughout all mission phases.

Arguably, OODA may seem overly simple for visualizing the complexities and interdependencies of irregular warfare. However, FM 6.0 stresses how OODA integrates multi-echelon operations with multiple and interdependent perspectives. *End State* stresses the need to visualize and coordinate the action cycles of many external players to include civilians, sheiks, the Iraq Army, and Iraq Police.

The four phases of the OODA cycle were established as cornerstones of *End State*'s training design. A set of visualization skills were identified that correspond to the four phases of OODA:

- Observe and envision the AO in 2D, 3D and 4D
- Observe and envision the AO's METT-TC factors
- Orient the unit for maneuver, action, and coordination
- Orient external players for maneuver, action, and coordination
- Decide what information is needed for current and future action
- Decide what actions are needed for current and future situations
- Act on emerging threats
- Act on emerging opportunities

Design and Development of End State

End State is an interactive training product with instructorless coaching to improve commander's ability to visualize small unit operations in irregular warfare. The design of *End State* is based on ARI's well-established approach to deliberate practice and the development of cognitive skills in realistic settings, such as Iraq.

Training Vignettes

End State has 14 sequential training vignettes featuring a cast of 3-D company-level avatars interacting with a

variety of combatants and noncombatants in their AO located in Kirkuk, Iraq. The storyline across vignettes follows Captain Dukes of A/2-5/15 IN as his unit initially deploys and then conducts full-spectrum operations in Iraq. A phantom character called Major Harris, who was Dukes' former small-group instructor in MC3, serves as Dukes virtual mentor. Progression through the training links thought to action by pairing each reflection vignette with a subsequent action vignette, as shown in the Course Map in Figure 4. For example, Captain Dukes mentally rehearses how his unit will escort a medical convoy during vignette 2a *Escort Convoy*, and then he conducts that mission in vignette 2b also titled *Escort Convoy*. This reflect-act cycle and CPT Dukes' imagined dialogues with Major Harris were adapted from the training classic *The Defense of Duffer's Drift* (Infantry Journal, 1905).

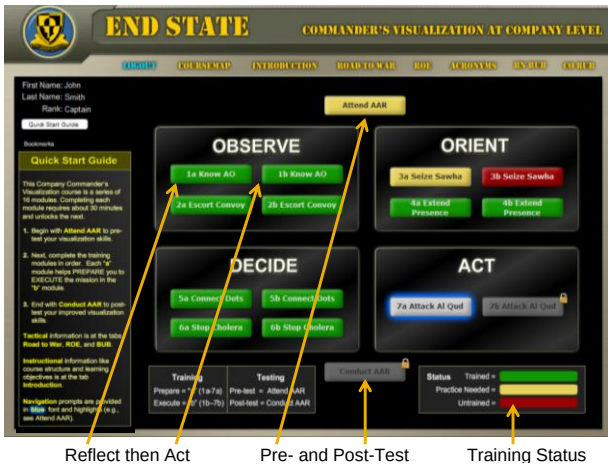

Figure 4. Course Map in *End State.*

The *foremost* design objective was to ensure that the training provides authentic expert guidance and feedback on how to form and refine commander's visualizations. The vignettes afford deliberate practice opportunities coupled with the immediate feedback needed to develop expertise (Ericsson, 1996).

The Course Map for *End State*, see Figure 4, is the learner's start point and access menu to all training, testing, and orientation components. The Course Map continuously indicates and updates the learner's current status on each training and testing vignette with the color green for "Trained," yellow for "Practice Needed," and red for "Untrained." Training status is based on learner responses to the over 75 checks-on-learning called "thought prompts" that occur during the 14 training vignettes, or modules, that span the OODA-based cycle of visualization skills. Test status is based on learner responses to the 16 assessment items in both the pre- and post-test.

All thought prompt items and test items are presented in multiple-choice format which supports objective and automated scoring. Both thought and test items require respondents apply their visualization skills to tactical problems that emerge during each vignette, rather than provide rote or declarative knowledge response.

Pre- and Post-Test Vignettes

To assess change in learner performance as a result of training, *End State* includes a pre-test vignette, called Attend AAR, and a post-test, called Conduct AAR. Each test assesses learner visualization skill via a series of 16 multiple-choice questions. In the pre-test, Captain Dukes attends an AAR on his unit's new AO that is being conducted by the outgoing company commander named Captain Sullivan. The pre-test items emerge naturally from the avatars' conversation and reflection during the AAR. Each learner's response to the test items is used to assess that learner's visualization skills before *End State* training has begun.

The post-test uses an analogous format, but now Captain Dukes is the outgoing commander conducting an AAR with his unit and a new incoming company commander. After completing each test, the learner receives pre- and post-test summary scores and by-item feedback. For performance assessment by trainers and training developers, *End State* records pre- and post-test data as well as thought prompt data in XML format for easy export into a digital database. The pre- and post-test data enable a comparative and quantitative assessment of learning as a result of *End State* training.

EVALUATION TWO: FORMATIVE EVALUATION

After development of the Alpha version of *End State*, a formative evaluation reviewed and refined the product before pilot implementation and validation.

Method

Forty-eight male officers nearing graduation from MC3 RC at Fort Knox participated in the Alpha review. Eighty-three percent (40/48) were captains and the remaining participants were lieutenants, and nearly all were armor and infantry officers. Seventy-five percent (37/48) were veterans of operations in Iraq or Afghanistan, many with multiple deployments.

All Alpha review sessions were conducted in a conference room at the ARI Fort Knox Research Unit. Three to five workstations were assembled with dual monitors so that up to 10 participants, working in pairs, could review the vignettes. Three to four members of the research team were present at each review session

to administer surveys, observe and record observations, and lead a focus group discussion on *End State*. After an orientation brief on the review's purpose and design of *End State*, participant pairs progressed through each of the assigned vignettes including the thought prompts and test items. Participants were provided a text copy of each of their vignette's storyboards for making additional comments.

Notably, no more than three vignettes were reviewed in a single session due to limited troop time available, and therefore no participant reviewed the complete training product. When the vignette reviews were completed, participants filled out a survey designed to capture their impressions and recommendations about the training product. Each session concluded with a focus-group discussion on the training's content, accuracy, and relevance, the product's clarity and usability, and participant recommendations for product refinement.

Results

Overall, the majority of the military participants in the Alpha review rated the *End State* product as effective, relevant, and worth using. Many recommended the training target junior commissioned and non-commissioned officers in the formal education process (e.g., the Primary Leadership Development Course). The participants' extensive experience in OEF/OIF may have tempered their need or desire for additional training on visualizing operations in Iraq, but it also underscores the credibility of their support for *End State* and recommendations for product refinement.

The majority of all Alpha review participants positively agreed with all of the 17 survey statements about *End State*, as summarized in Table 2. The average rating that test participants assigned to each statement from the Student Impressions Survey are provided in Table 2 (1 = Strongly Disagree; 3 = Neither Agree or Disagree; 5 = Strongly Agree). The far right column of this table shows the p-value for the one-sample t-test conducted on each of the ratings.

Because average ratings hovered around 3 and 4, each rating was tested for its difference from 4 (Agree) in order to evaluate participants' general agreement with each statement. Because 17 related one-sample t-tests were carried out, all p-values were corrected for familywise error rate by use of Bonferroni formula. That is, the conventional significance criterion (.05) was divided by the number of t-tests performed, producing a corrected p-value of .003. This t-test approach was adopted to provide a "strong" and relatively critical focus on identifying any potential changes to *End State*, per the objectives of the formative evaluation.

Table 2
Student Impressions Survey Data

Topic By Category	Mean	SD	*t-test p-value*
Usability			
1. Easy to navigate	4.12	.677	.180
2. Media worked well	4.02	.688	.849
3. Easy to understand	3.98	.635	.837
4. Time-to-train good	3.93	.525	.322
5. Clear objectives	3.53	.799	.000*
6. Clear assessments	3.53	.977	.001*
Relevance			
7. Relevant content	3.81	.783	.070
8. Interesting/engaging	3.88	.727	.211
9. Key tasks	3.52	.822	.000*
10. Realistic tasks	3.81	.661	.033
11. Realistic animation	3.60	.836	.001*
12. Valuable learning	3.82	.571	.024
Effectiveness			
13. Tactically sound	3.60	.821	.000*
14. Effective learning	3.79	.647	.017
15. Assessment fitting	3.40	.923	.000*
16. Feedback valuable	3.59	.826	.000*
17. Use and recommend	3.70	.829	.008

Note: Rating scale ranged from 1= Strongly Disagree to 5 = Strongly Agree. Asterisk indicates item significantly below "Agree."

As shown Table 2, participants agreed that *End State* was easy to navigate and functioned properly (survey Statements 1 and 2). Test participants also agreed that they could orient themselves well in the 3D environment and that the vignettes took an acceptable amount of time to complete (Statements 3 and 4). Content relevance and media mix (Statements 7 and 8) earned mean ratings slightly, but not significantly, below 4. Average ratings for survey Statements 10, 12, 14, and 17 also did not differ significantly from 4 indicating test participants' general support of the *End State* learning design and content.

Ratings for Statements 5, 6, 9, 11, 13, 15, and 16 were significantly different from 4 (Agree), indicating that overall the test participants did not fully "agree" with these survey statements. Most such survey statements on which test participants indicated ambivalence were related to aspects of *End State* with anticipated shortfalls, based on in-house review and the generally acknowledged difficulty in objectively scoring tactical expertise. In particular, some test assessment items were rightfully criticized.

Participant ratings and comments on assessment items (Statements 6, 15, 16) provided data and constructive suggestions for revising the wording, response options, and scoring for training and test items. Participants also discovered that scoring on a few thought prompts did not function properly (e.g., the answer keys were incorrect).

Statements 11 and 13 addressed 3D realism and tactical soundness. Some 3D sequences were inevitably "limited" by production cost and several of the draft vignettes had distracting subject matter inaccuracies (e.g., tactical movement in vehicles without gunners, etc.).

Statement 5 addressed clarity of the training objectives. However, as noted due to troop time available, the participants completed only the modules assigned and most participants did not receive the introductory module "Know Your AO" (7a) that provided an overview of the visualization training objectives. Similarly, Statement 9 read: "All of the key aspects of company-level visualization are addressed by the visualization skills described in the training." The use of "All" now seems inappropriate with respect to such a higher-order skill and the fact participants reviewed only a subset of the complete training program.

Finally, Statement 17 addressed the key issue of how worthwhile the training might be in improving unit performance. Overall, 70% of the participants rated Agreed or Strongly Agree to: "I would use this training to improve my own unit and recommend this training to others." However, 21% provided a rating of 3 (Neither Agree or Disagree; 7% or two participants provided a rating of 4 (Disagree); and one participant strongly disagreed. Comments by participants that disagreed particularly underscored the problem of time to train given the demanding schedules created by today's deployment and operational tempo. For example, "There is already so much "mandated" pre-deployment training. I don't have time for more." More ambivalent participants (21%) to this item also noted their concerns about training time constraints and, most frequently, the need to revise the wording, response options, and scoring for certain training thought prompts and test items.

Many of the participants recommended *End State* across the full range of small unit leadership positions, including its use as refresher training. Participants stressed *End State*'s potential value in the education of junior commissioned and non-commissioned officers, and especially those not yet deployed.

Discussion

Based on the results of the formative evaluation, many revisions were made to the Alpha version of *End State*, within the constraints of project scope. As a result, the current version represents a Beta release of *End State* (ARI, In preparation). The Alpha review participants provided numerous constructive suggestions for improving the training, particularly *End State*'s visualization imagery, thought prompts, and the expert guidance and feedback. Because it was not possible to address all recommendations made by the review participants, targets for revision were prioritized on the basis of their instructional value, feasibility, and cost-benefit.

The most important targets identified for revision were the thought prompts and changes to imagery and text/narration to enhance doctrinal accuracy. Thought prompts are considered the heart of the *End State* training design, providing learners with numerous opportunities for deliberate reflection and practice in the development of visualization skills. The ultimate focus of *End State* is learning versus external evaluation.

Accordingly, the thought prompts require three attempts, as needed, with explanatory feedback from experts provided for every response on each attempt. If revisions were not made to the thought prompts, a foundational instructional strategy built into the system would not be implemented effectively. Moreover, content and functional errors with the thought prompts are much easier to repair relative to revisions in 3D animation sequences.

Refinements made to thought prompts and test items, and now in the Beta version of *End State*, focused on revisions to the problem space as well as the expert explanatory feedback that participants receive on their responses to thought prompts. The primary revisions involved correcting all automated scoring key issues, modifying question stem and response option wording and format, clarifying expert explanatory feedback, and changing static 2D visuals to enhance doctrinal accuracy. Refinements made to visualization imagery included more extensive use of still and animated visuals to bolster the learning process and enhancements to the consistency and currency of visuals representing the operational environment.

EVALUATION THREE: PARALLEL TESTS

After refinements were made to *End State* based on the formative evaluation, research was initiated to ensure parallel pre- and post-tests in order to assess training effectiveness and build normative standards.

Parallel Test One

Measurement is essential to training, and parallel tests provide a firm basis to assess training effectiveness and establish normative skill standards. Requirements for parallel tests generally include common general and group factors (e.g., visualization skill and sub-skills),

equal true score means, standard deviations and item inter-correlations (Clause, Mullins, Nee, Pulakos, & Schmitt, 1998).

Method

Thirty-one Soldiers participated in the first evaluation of parallel tests conducted at Fort Campbell, Ky. All, but one, were lieutenants and captains recently returned from Afghanistan, and four had earlier tours in Iraq.

After an introductory brief on the purpose of the research and visualization training effort, each Soldier completed a hard-copy version of either the pre- or post-test from *End State*. Next, each Soldier completed a test review booklet which asked a series of questions about each of the 16 test items. Finally, the Soldiers in each session engaged in a small (5-6 participants) group discussion led by a co-author recently deployed to Iraq and now retired from the military.

The review booklets included open-ended questions for comments and recommendations, and a series of item quality statements to be rated. The rating scale ranged from 1-4 (1 = Strongly Disagree to 4 = Strongly Agree) with higher ratings indicating greater agreement with each item quality statement. Item quality statements for each pre- and post-test test item addressed: how confident the participant was that their answer was correct, whether the test item was relevant to company visualization, whether the test item and "problem set" provided adequate information, whether the wording of the question was clear, whether they believed the answer scored as "correct" was accurate, and how realistic the item was in terms of reflecting the operational environment of irregular warfare.

Results

Analysis of the results included independent t-tests to examine differences between the pre- and post-tests on the participants' mean test scores (percent correct) and item quality ratings.

Mean test scores were 46% (SD = .10) on the pre-test and 58% (SD = .15) on the post-test. A significant difference was found between pre- and post-test mean scores [$t(29) = 2.53$, $p < .05$, $d = .941$]. Mean item quality ratings were 3.03 (SD = .279) on the pre-test and 3.05 (SD = .258) on the post-test, with no significant difference.

Additional analyses compared test score and item quality ratings on each pre- and post-test item. The pre-test had four items that nearly all participants answered incorrectly. However, the average quality ratings on these four items were not low, relative to their ratings on other items. The pre-test also had more items that needed better problem-set information and clarity, based on participants' ratings and comments. The two tests had about equal number of items with average ratings of 3 (Agree) or higher on key quality items such as accuracy, relevance, and realism. These results suggest that that the differences in test performance may be due, in part, to post-test items that were easier to understand and provided better context support to the participant.

Discussion

Based on results of the Parallel Test One evaluation, substantial revisions were made to items in both the pre- and post-tests for *End State*. Qualitative data from participants' review booklets and discussion comments were used to revise test items for clarity and relevance, and to equate the tests and test items for difficulty. Items receiving particularly low scores were closely reviewed and revised, per Soldiers' recommendations and clarifications. The 16-item bank of questions in the pre-and post-tests was expanded to 22 items to examine wording variants and to adjust for content validity by overall visualization skill and the four OODA cornerstones of *End State*'s training design.

Parallel Test Two

The revised versions of the tests were administered during the Parallel Test Two evaluation at Fort Knox.

Method

Fourteen soldiers from MC3 RC participated in the data collection effort. All were commissioned officers including 10 captains, 3 lieutenants, and 1 major. All, but one, had deployed to Afghanistan or Iraq, and 3 had experienced multiple deployments.

Unlike Parallel Test One, all participants in the second evaluation completed *both* tests and then completed a test review booklet (similar to the first evaluation's booklet) on their last test completed. Like Parallel Test One, the procedure was: introductory brief, hard-copy tests, review booklet, and lastly group discussion led by the same co-author. For the two sessions, test order was counter balanced and participants were evenly divided into two discussion groups.

Results

Initial analyses identified two pre-test items and one post-test item that were excluded from the test banks and from subsequent analyses, based on test scores and participants' ratings and comments.

Mean test scores were 66%, (SD = .11) on the pre-test and 67% (SD = .11) on the post-test, and the difference was not significant [$t(13) = -.137$, $p > .05$]. Mean item

quality ratings were 3.00 (SD = .11) on the pre-test and 2.99 (SD = .29) on the post-test, with no significant difference.

Discussion

Results from the Parallel Test Two evaluation indicate that significant progress was made toward establishing parallel test forms. The mean test scores and standard deviations were nearly identical. Similarly, the item quality ratings were nearly the same and indicate positive agreement, particularly on more important statements assessing item difficulty and relevance.

However, additional item revisions are planned for the Parallel Test Three evaluation scheduled for late July 2009 at Fort Bragg. These revisions will be based on the objective and subjective data already collected, and an ongoing detailed item analysis.

Anticipated results of the Bragg data collection are to shed the least useful of the remaining test items and return to a final 16-item test bank for both the pre-and post-test. Item selection will include consideration of common general and group factors (e.g., visualization skill and sub-skills), equal true score means, standard deviations, and item inter-correlations. An important expectation is that the Parallel Test Three evaluation will result in parallel tests.

CONCLUSION

The *End State* product (ARI, In preparation) is now available as a Beta release for pilot implementation and further research. Ongoing research by ARI and pilot implementations by U. S. Army trainers and Soldiers will determine the value of *End State* for improving the visualization skills needed in today's operational environment.

The *End State* product has been provided and briefed to a number of potential training audiences including III Corps at Fort Hood, the Future Force Integration Directorate at Fort Bliss, and MC3 RC at Fort Knox. ARI's future research on *End State* is focused on further transition to junior commissioned and non-commissioned officer training audiences including the Primary Leadership Development Course, the Basic Non-Commissioned Officer Course (BNCOC), the West Point Military Academy, and the Reserve Officer Training Corps.

In summary, research by ARI is now addressing three key goals that will support *End State*'s validation and utilization. The initial goal is to develop parallel pre- and post-test forms for *End State*. A related goal is to establish normative standards of visualization skill at small unit levels that distinguish novice, intermediate, and expert performance. Normative standards should provide an empirical data base for understanding and improving visualization as well as a diagnostic tool on the acquisition and maintenance of visualization skills.

The final research goal is to examine the training effectiveness of *End State* based on parallel pre- and post-tests and ultimately on job-related performance metrics. The desired end state of ARI's research on *End State* is to improve commanders' ability to visualize irregular warfare. Training to fight irregular warfare is imperative to winning the fight.

DISCLAIMER

Views expressed in this paper are the authors and not the official position of the U.S. Army.

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