Rapid Development of a Mixed-Media, Deployable Counter-IED Trainer

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ABSTRACT

In February 2009, the Institute for Creative Technologies (ICT) at the University of Southern California was contracted to develop a training system for Soldiers and Marines. The goal of the training system was to reduce the number of casualties caused by improvised explosive devices (IEDs). Over the next five months, a team at the ICT drew on subject-matter experts' input, findings from cognitive psychology, and cinema-style script-writing to achieve this goal. The result is the Mobile Counter-IED Interactive Trainer (MCIT), a narrative-focused, mixed-media training simulator that can be deployed anywhere in the world. This paper details the course of MCIT's development, from initial concept to working prototype to finalized training system. We also discuss the technical challenges of developing in VBS2 and the changes driven by user feedback throughout the development process.

ABOUT THE AUTHORS

Dr. Matthew Jensen Hays is a Postdoctoral Research Associate at the University of Southern California's (USC) Institute for Creative Technologies (ICT). He received a B.S. in Psychology from Duke University in 2002. He then worked with the Duke University Medical Center's radiology department to revise the interfaces used by technicians to control imaging devices. He received an M.A. and Ph.D. in Cognitive Psychology (with a minor in Human-Computer Interaction) from the University of California, Los Angeles (UCLA) in 2006 and 2009, respectively. Before joining the ICT, Dr. Hays worked to develop training programs and assessments at UCLA's National Center for Research on Evaluation, Standards, and Student Testing. At the ICT, Dr. Hays has performed several empirical evaluations of the pedagogical value of ELECT BiLAT (an immersive, cross-cultural negotiation trainer). The publications resulting from these efforts have received Best Paper Awards at conferences in 2008 and 2009.

Ms. Teri M. Silva is a Project Specialist at the ICT. She graduated from Brown University with a B.S. in Psychology in 2007. While at Brown, she began using virtual reality to explore navigation and locomotion in virtual environments. After graduating, Ms. Silva began working at the ICT on projects dedicated to using virtual environments to treat veterans with post-traumatic stress disorder. Her current work is focused entirely on the development and evaluation of counter-IED training systems.

Dr. Todd Richmond is a Project Director at the ICT. He entered college as a music major (an interest he continues to pursue as a performing bassist/guitarist/vocalist in a variety of ensembles) but graduated with a B.A. in chemistry. Dr. Richmond went on to earn a Ph.D. in chemistry from Caltech and following a postdoc at UCSF he accepted a faculty position at The Claremont Colleges. Early in his faculty career he incorporated multimedia and Web technologies into his teaching and research. That work led him to evolve from his specific focus on chemistry to instead pursue a broader understanding of the intersections of technology and content. He moved to the USC Annenberg Center in 2000 as managing director, researching trends in new media while fostering emerging technologies for collaboration and learning. Currently at ICT, Dr. Richmond works in a variety of areas including: counter-IED training systems involving video narrative, immersive environments and geo-specific multiplayer gaming scenarios; interactive education including serious games and simulations; visualization, messaging, and media as agents of change; viral media and building learning communities. He also is a writer, photographer, and filmmaker, having produced/directed a series of "mini documentary" projects as well as numerous new media pieces.

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OVERVIEW

Improvised explosive devices (IEDs) are, simply, bombs. A bomb becomes an IED when it is used for something other than conventional warfare. *Conventional warfare* is a public confrontation in which the primary participants are known and the target is the opponent's military force. *Unconventional warfare* is also intended to achieve military victory, but through other means. One example is terrorism, which is often intended to frighten the opponent's citizens into withdrawing their military's support. Another use of IEDs is to convince the opponent's leaders that a stable, peaceful outcome is impossible—that they should simply abandon their mission. The effects of IEDs thus extend well beyond the direct consequences of detonation.

Any explosive material can be used to make an IED. For example, vehicles can be loaded with combinations of fuel and fertilizer and driven to their target (e.g., the 1995 Oklahoma City bombing). IEDs can also use high-yield, well constructed materials. A common practice among insurgents is to recover unexploded bombs dropped by opponents and to convert them into devices that detonate on command. The triggering mechanisms are as diverse as the explosives themselves: radio-controlled (e.g., cell phones, baby monitors, garage-door openers), command-wire detonated, victim-operated (e.g., trip wires, pressure plates)—and that list is far from exhaustive.

IEDs are effective because their patterns of use differ from patterns established by millennia of conventional warfare. Their variety and portability can further intimidate opponents' forces. In many cases, a primary consequence of that intimidation is that insurgents' opponents will avoid an area in which IEDs are known to be used: the first step toward victory in an unconventional war. A secondary—and more insidious—consequence is that insurgents' opponents in an IED-prone area will become less effective. Under duress, recent training can be lost while old habits re-emerge (e.g., Beilock & Carr, 2001). Thus, even advanced, effective training may not be able to be used when a situation in which it is needed arises. The stress caused by IEDs may cause Coalition forces to revert to less effective tactics, techniques, and procedures (TTPs). This regression may be part of why IEDs were responsible for more than 50% of Coalition forces casualties in Afghanistan in 2009.

THE REQUEST

In July 2008, a United States Central Command (CENTCOM) memo by MG Curtis M. Scaparrotti identified IEDs as a significant, continuing impediment to Coalition forces' efforts. Attempts to summarily defeat IEDs had not had substantial measurable effects. The memo further noted that a focused training effort with specialized capabilities needed to be established so that Coalition Warfighters would be able to effectively operate and maneuver on their patrols. The memo also outlined training requirements for counter-IED behaviors on both individual and collective levels.

At the time, there were two types of counter-IED training. First, before being deployed overseas, some Warfighters received PowerPoint briefings or watched videos about IEDs. They may also take an "IED Walk," which is a path along which IED models are emplaced, accompanied by descriptive placards (Figure 1).

FIGURE 1. AN INSTALLATION ON AN IED WALK

The second type of counter-IED training was provided overseas by various task forces. This follow-on training was designed to allow Warfighters to practice applying their knowledge of IEDs, thereby honing their skills. This practice featured guided and unguided navigation of high-risk search courses in which an IED was known to have been emplaced.

As with any approach, these two counter-IED training methods had drawbacks. First, PowerPoint lectures and the IED walk are almost entirely passive pedagogical tools. As a result, they affect low-level learning (i.e., recall and recognition), but do not encourage the transfer of knowledge to other situations (Anderson & Krathwohl, 2001; Bloom & Krathwohl, 1956). To promote deep learning that could be applied in other situations, trainees must be actively engaged in their training tasks (e.g., Evans & Gibbons, 2006; Vogel et al., 2006).

The second training approach—real-world IED search courses—are time-consuming to set up and modify. Even small position changes in theater can be accompanied by dramatic terrain differences (e.g., moving from a desert area into mountainous region). The corresponding insurgents' TTPs may be dramatically different. It is almost impossible to simulate a mountain on an IED search course constructed on flat land. In response to this restriction, new training needed to offer a variety of scenarios and have the ability for new scenarios to be developed quickly.

Finally, both of these training approaches were entirely oriented to the perspective of the Coalition Warfighter. Perhaps taking the insurgents' perspective would better allow Warfighters to predict their behavior, particularly with regard to IED emplacement and strategy (Galinsky, Maddux, Gilin, & White, 2008). Alternatively, it may be that the best way to understand insurgents' TTPs is to use them. To that end, the new training needed to provide firsthand insight into the insurgent mindset.

MG Scaparrotti noted that there would never be a technological "silver bullet" for defeating enemies' IED use. Nevertheless, technology would play a critical role in reducing IEDs' effectiveness—both for operations and training. The need was for a pragmatic prototype system that could be used to train troops as well as to inform the development and evolution of various approaches. The prototype system had to draw on every available tool, from research on cognitive psychology and training to Hollywood storytelling and stagecraft—and it needed to be developed as quickly as possible.

The ICT was uniquely positioned to respond to this request. Part of the ICT's mission is to develop research prototypes that can be transitioned into programs of instruction (e.g., Kim et al., in press; McAlinden, Gordon, Lane, & Pynadath, 2009). More broadly, research at the ICT encompasses virtual humans, natural language processing and generation, learning sciences, advanced graphics development, immersive simulation, production-quality narrative and storytelling, and serious games. Finally, the ICT has a track record of developing high-quality immersive training systems in minimal time.

The initial concept for the training system was that it would be housed in 40-foot-long ISO Container Express Boxes (CONEX Boxes, or CBs). This concept was brought to the ICT by the project sponsor (the Joint IED Defeat Organization Joint Center of Excellence), which had worked with a contractor (AT Solutions) to develop an early, rough proof of concept. With this initial concept, researchers, engineers, and programmers at the ICT worked to flesh out the details of the training system. Six weeks after learning of the requirements in early November 2008, the ICT submitted a detailed proposal for the Mobile Counter-IED Interactive Trainer (MCIT).

The importance of this training system was clear from the beginning. The ICT was informed that their first deliverable would need to arrive at Ft. Bragg (North Carolina, USA) by June 2009—less than six months after contract. Trainees' responses to that system were to be integrated into subsequent MCIT deliverables to be deployed within the next few months in an iterative development process.

THE DESIGN

The system proposed by the ICT was called the Mobile Counter-IED Interactive Trainer (MCIT). MCIT was designed to address the weaknesses of the training programs described above. It had to be able to be delivered to trainees at a variety of locations; it had to avoid relying entirely on passive instructional approaches; it had to be able to be updated as new information became available; it had to demystify the strategy and tactics of IED use; and, most of all, it had to provide training that would not be lost under duress—when it was needed most. Further, although Warfighters encounter IEDs during both mounted and dismounted operations, MCIT was initially limited to mounted patrols and the associated TTPs. This restriction was imposed in order to simplify the design and enforce a reasonable scope on the training (which had a time limit of approximately 1.5 hours). Finally, it was critical that the simulated missions in MCIT be conducted in geo-specific locations.

Available Anywhere

MCIT comprises four CBs, each of which is 8' wide, 9.5' tall, and 40' long. These and their ruggedized contents can be loaded onto a C5 Galaxy or C17 Globemaster, which can then deploy them anywhere in the world. In this way, the training system can be brought to the Warfighter, rather than the other way around.

Further, by having four separate "rooms" for training, fireteams can be trained in parallel. The MCIT experience involves a sequential procession through the four trailers; when one fireteam has progressed to the third room (CB3), the other two fireteams (3-4 Warfighters) are simultaneously being trained in CBs 1 and 2. (Figure 2 portrays an external view of the MCIT trailers.) As a result, up to 12 people can complete their training in MCIT in approximately 90 minutes.

FIGURE 2. MCIT EXTERIOR

Engaging Instruction and Interactive Practice

MCIT was designed to train via a combination of direct instruction (Schwartz & Bransford, 1998) and simulated practice (Schmidt & Bjork, 1992). Rather than using PowerPoint lectures to provide the instruction, we chose to use an engaging narrative accompanied by rich, detailed exhibits designed by Hollywood set-builders. This decision was intended to improve trainees' attention and, thus, their learning (e.g., Malone & Lepper, 1987). Some video screens in CBs 1-3 therefore portray the story of PFC Owen, a fictional Soldier on patrol in Afghanistan. Owen's experiences are relayed via video journal clips ostensibly intended for his little brother, who is a civilian in the United States.

Rather than using a real-world IED course to provide training, we chose to develop a *first-person-perspective* simulation, meaning that the trainees see through the eyes of the participants in a virtual convoy. (An alternative to first-person perspective would be third-person perspective, where the trainee would control a character from an over-the-shoulder or top-down viewpoint.) This approach was chosen so that their practice would more closely resemble the situations in which their training would be called upon, which has been shown to improve transfer task performance (e.g., Morris, Bransford, & Franks, 1977).

To guide us in generating content for the exhibits and videos in CBs 1-3 and the simulation in CB4, we relied on input from several subject-matter experts (SMEs). The experts we interviewed had considerable experience in the domain of convoy operations, specifically IED recognition and reaction to potential and confirmed IED threats. Unfortunately, standard interviews with experts may unintentionally omit up to 70% of their domain knowledge (e.g., Chao & Salvendy, 1994). This omission is because experts' knowledge has become *automated*, meaning that it is no longer available for unprompted conscious retrieval (e.g., Singer, 1968). In other words, rather than following a discrete set of procedures, the components of experts' abilities are things that they "just know" or "wouldn't know how to not do." Our SMEs were able to predict when IEDs were nearby when the "hair stood up on the back of [their necks]" or "something looked wrong." Over several days, the SMEs were therefore interviewed using a technique called cognitive task analysis (CTA). A CTA involves a set of structured questions and follow-ups that allow the interviewer to break down expert knowledge into its component tasks—to find out what made "something look wrong" (Clark & Estes, 1996; Clark et al., 2007). The results of this CTA were then integrated into exhibit design and simulation scenario development.

Demystifying the IED

During the CTA, the SMEs repeatedly emphasized the psychological impact of IEDs. Many IEDs never detonate, and many others detonate without injuring Coalition Warfighters. However, *every* IED has the *potential* to do so. This uncertainty has an even greater likelihood of impairing Warfighter effectiveness because many Warfighters do not understand how IEDs work, how they are used, or insurgents' motivations for using them.

In response to the SMEs' statements, we worked to ensure that IEDs were demystified throughout MCIT training. By reducing fear, the training provided by MCIT is thus more likely to remain available even in the high-stress situations associated with encountering and responding to potential IEDs in theater (e.g., Beilock & Carr, 2001). To achieve this goal, some video screens in CBs 1-3 complement Owen's story with videos that make IEDs—both their dangers and their weaknesses—concrete to the trainees. These videos are provided from the perspective of an insurgent. Specifically, they are ostensibly recorded messages from an insurgent leader to a subordinate, both of whom are involved in plotting an attack on a Coalition convoy.

The static contents of CBs 1-3 supplement the video narratives, familiarizing trainees with types of IEDs and their use. The main theme of CB1 is that "IEDs are nothing new." (Figure 3 depicts the interior of CB1.) Although widespread awareness of IEDs is relatively recent, they have been used effectively since at least the American Civil War. Providing trainees with this information is intended to increase their confidence that, by now, IEDs and their tactics are relatively well understood—and can be defeated.

FIGURE 3. CB1 INTERIOR

CB2 delves more deeply into the insurgents' perspective. The room's floor plan, decoration, and contents are those of an IED-making insurgent's home. The walls feature maps of frequently used Coalition convoy routes (a point of emphasis in MCIT is to avoid being predictable), and the furniture is built to feature hiding places for IED components. A workbench is littered with components for creating IED switches and containers, including explosively-formed penetrators (EFPs).

CB3 focuses on the methods by which IEDs can be defeated. CREW devices are emphasized, both in terms of the protection they provide and the types of IEDs against which they are ineffective. Trainees are also taught simple behaviors that can translate into significant setbacks for insurgents. Throughout the experience, the insurgent storyline and the Owen storyline are balanced so that the dangers of IEDs were portrayed without shaking trainees' confidence that they could be defeated.

CB4 features a first-person team-based simulation of a mounted patrol. Trainees participate as if they were directly involved in the scenario. They drive mock-HMMWVs (complete with real seats, steering wheels, FBCB2 Tracker, a gun turret, and a rumbling motor), call in IED and CASEVAC 9-lines, and stay in constant communication—a critical element of IED defeat. They view the virtual world through large flat screen monitors mounted in the HMMWVs (shown in Figure 4). Like the first three trailers, this simulation includes the perspective of the insurgents, as well. While two of the three fireteams take the roles of HMMWV crews (BLUFOR), the third fireteam takes the role of OPFOR. As insurgents, this group of 3-4 trainees first surveys the terrain, chooses an attack point, emplaces an IED and carries out a complex attack on the BLUFOR convoy with AK-47 assault rifles and rocket-propelled grenades (RPGs).

FIGURE 4. PATROL SIMULATOR (DRIVER AND TEAM CHIEF POSITIONS)

After a patrol is completed, the fireteams switch roles and another mission begins. This process is repeated once more; in total, each fireteam takes the role of the rear HMMWV in a patrol, the lead HMMWV, and then the OPFOR. Because humans play the role of OPFOR and they can place a device nearly anywhere along the convoy route, no two simulations are the same. Even if the OPFOR decides to place the IED in the same place on three successive runs, they might stagger the RPG attack differently, or the BLUFOR might take a different path along the route. Anecdotally, we have observed shifts in strategy across runs; the lessons transfer, and the trainees come to understand how the OPFOR can use terrain as a devastating weapon. By the time they play as OPFOR, their strategies are already quite advanced. However, they also learn—and discuss—how the BLUFOR can defeat that weapon by being mindful of line-of-sight issues with CREW and threat detection, IED markers, and the mechanics of complex attacks.

Flexible Training

If insurgents' TTPs never changed, counter-IED training would never need to be updated. In reality, IED materials, triggers, and strategies continually evolve and spread throughout different regions at different rates. Further, as insurgents strike or Coalition forces make progress, the features of the regions (e.g., population density, population hostility, road quality, variations in elevation) change, as well.

To respond to the ever-changing face of counter-insurgency efforts, each successive MCIT prototype has been designed to be more adaptable. When an IED is detonated in theater, information about it is collected by Weapons Intelligence Teams. This information can be used to generate new types of IEDs for the OPFOR to use against the BLUFOR in MCIT. The same is true for triggers, delivery mechanisms, and IED indicators (e.g., a pile of rocks or downed telephone pole used by insurgents to time their attack as a convoy passes by).

Perhaps MCIT's most significant advantage over a non-virtual IED practice scenario is in its ability to rapidly offer new geo-specific terrains (i.e., virtual versions of real-life locations). From the time satellite data about a terrain are received, developing a route and populating the scenario with vegetation, buildings, and other assets (e.g., rocks, vehicles) takes programmers and artists at the ICT less than one month. The results of these efforts are striking: "I bought a [soda] in that building," said one trainee who had returned from deployment in an area portrayed in MCIT.

MCIT's flexibility extends beyond the simulation in CB4. The first three trailers default to a "walk-and-pause," meaning that trainees are advanced through the room after each video is completed. This is achieved by dimming the lights near the video screen that has just finished playing its contents while raising the lights near the next video screen and the accompanying exhibits. However, if trainees have more time, CBs 1-3 can be switched to "museum mode," which gives trainees unlimited time with all lights activated so that they can peruse the exhibits and activate any video at will. Other features can be changed as well. The OPFOR (CB2) and BLUFOR (CB3) versions of the route map can be swapped for whatever simulation is loaded up in CB4. Even the static exhibits are designed to be modular, so they can be swapped for new ones with updated information. A primary goal of MCIT is to never provide negative training. We therefore built MCIT so that, if we uncovered information that contradicted the content we had created, it would be relatively easy to remove that content.

The topic of flexibility brings up a final component of CBs 1-3 that deserves mention: the quiz stations. At the end of CB1, the end of CB2, and the beginning and end of CB3, touchscreen computers ask trainees to answer a few questions about what they have learned or what they remember from previous trailers. The questions do not focus on regurgitation of TTPs or "facts," but rather use a "keep in mind" approach to assess and remind trainees about the importance of situational awareness. The quizzes are integrated with a broader learner management system, which tracks users as they proceed through the system. The quizzes use HTML and Flash, meaning that they can rapidly be changed to accommodate new content—or improved questions. It is important to note that these quizzes are not just diagnostic tools, but can actually help reinforce the lessons. The *testing effect* is the robust finding that having to retrieve information is much better for long-term memory than is simply being shown the information again (e.g., Roediger & Karpicke, 2006). Even if trainees fail to correctly answer questions, the stations provide feedback and the relevant skills are used in CB4. Both of these fallbacks are designed to ensure that trainees are better able to retain what they learn in CBs 1-3 (Kornell, Hays, & Bjork, 2009).

Responsive to User Feedback

After delivering the first prototype to Ft. Bragg, we observed trainees' use of and response to MCIT. We also conducted brief interviews after they had proceeded through CBs 1-3 and CB4. Our goal was to further refine the content and the process of training in order to improve the users' experiences. Fortunately, most of our initial design decisions were very well received. Of course, there were interface issues during the simulation in CB4 (e.g., the default reload time for the RPG was zero, allowing it to be fired semi-automatically), but we were able to note (and then correct) most of these in our development lab during weekly full-team play-tests of the system. However, there were two major revisions—one to CBs 1-3 and one to CB4—that could have emerged only as a consequence of user testing.

In our original design, trainees were shuttled through CBs 1-3 by a combination of sequenced overhead lights (described above) in concert with video screen activation. This decision was made based on our estimate that, while a video screen was active, the trainees would spend only about 70% of their time looking at the screen. The rest of the time, we believed, they would roam within the lighted area, looking at exhibits or chatting with the rest of the fireteam. In actuality, we had significantly underestimated the power of the narratives to command their attention. Well over 90% of the time, the trainees were glued to the stories in the videos. The ICT's Hollywood-quality scripts and production values were effective. Unfortunately, this focus of their attention on the screens meant that they did not engage the material presented in the exhibits. To encourage the trainees to examine the physical environment, we added two minutes to each quiz and turned up the lights throughout the trailer. We also revised the quizzes to include questions that require fireteams to send trainees to different exhibits to rapidly answer questions before time runs out. In this way, the quizzes became better instructional tools *and* the trainees' interactions with the exhibits became more guided—and therefore more pedagogically beneficial (Kirschner, Sweller, & Clark, 2006; Mayer, 2004).

The other major revision that occurred as a result of user testing had to do with the patrol routes in the simulation. The first four scenarios we developed for CB4 were 10-kilometer-long patrol routes. Along these routes, the OPFOR could choose from nine areas within which to emplace their IED. After selecting a location, the OPFOR chose where specifically to place their IED, what type of IED to use, how to conceal it, and how to detonate it. When that process was completed, they would then wait in anticipation for the BLUFOR to arrive. We discovered that the system operators were requiring the OPFOR to limit their selection to only the first three areas. Otherwise, it took so long for the BLUFOR to reach the OPFOR that there was insufficient time for three runs through the simulation. That is, the trainees were actually being more cautious and driving more slowly than we had predicted. We responded to this information by shortening all of the scenarios to be ~3.5 km long. We also added more emplacement areas within the shorter patrol route. In this way, repeated runs through the same scenario would almost never consist of repeated ambushes at exactly the same place. We have sustained this short-but-dense approach throughout our development of additional scenarios in the past few months.

THE CHALLENGES

In addition to our initial goals and feedback from users during development, external constraints also played a large part in shaping MCIT. Many of these constraints originated from the severely limited time-frame we were given to develop the system. These restrictions affected decisions about software and hardware and required us to make decisions that may be able to be avoided in a full-scale production version.

Software Environment

The most important consideration in developing the simulation in CB4 was which game engine to use. A *game engine* can be thought of as a library of assets, functions, and processes that work together to create an interactive experience for the user. For several reasons, we chose to use Virtual Battlespace 2 (VBS2). First, the U. S. Army had recently purchased a license for VBS2. As a University-Affiliated Army Research Center, the ICT saved substantial start-up time by selecting VBS2 instead of negotiating with several game developers to purchase a different engine. Further, VBS2 has a truly massive archive of assets (e.g., HMMWV models, Afghan and Iraqi buildings, and weapons), meaning that we could very rapidly offer our clients a proof of concept. Finally, VBS2 is able to load and render vast terrains, meaning that we could respond to any request provided for a patrol route (given that we were able to receive satellite and elevation data). This ability was critical to the simulation's fidelity. Rather than proceeding half a kilometer and then encountering a "Loading…" screen, they were able to proceed throughout a gigantic, geo-specific terrain without any immersion-breaking interruptions.

As we moved from broad brush strokes to finer ones, we began to encounter substantial difficulties with VBS2. Most of these difficulties can be traced to the way in which VBS2 allows programmers to control system variables (e.g., HMMWV speed). In early 2009, the VBS2 Army license did not provide direct access to the *source code*—the mechanics of the game engine itself. Instead, VBS2 offered a *scripting language*, which is a framework for creating commands and functions that affect some of the variables in the game engine. As we more and more frequently encountered situations in which we wanted to access variables not available to the scripting language, we were forced to develop time-consuming workarounds.

For example, we wanted to cause the firing of a weapon to “scare” the artificial-intelligence (AI) controlled civilians and animals in the game. The most straightforward approach would have been to rely on the *event* that is registered when a weapon is fired. Unfortunately, there was an error in the VBS2 code (a “bug”). This bug caused the “weapon fired event” to either not work or to cause computers to become desynchronized when connected over a network (i.e., the driver of a HMMWV would be several meters “ahead” of the gunner of the same HMMWV). With access to the VBS2 source code, we would have been able to debug this event and resolve the issue. Instead, we had to attempt to use the scripting language to get around the problem. Ultimately, we resorted to using a script to monitor the amount of ammunition in the weapons of each player; when this value decreased, they must have fired their weapon, and nearby AI characters were instructed to be frightened.

Having successfully frightened civilians near an insurgent, IED, or firing weapon, we encountered another difficulty. The default “frightened” behavior in VBS2 is for a character to get down on the ground in a prone position. However, one of the real-world indicators of a nearby IED is when the local population avoids an area that is usually crowded (e.g., a marketplace). We therefore instructed the AI to avoid (i.e., walk or run from) frightening situations. The going-prone and running-away behaviors became conflicted; civilians would go prone, start to get up to run away, and then go prone again. The visual result was a group of civilians doing push-ups—an unfair clue that an IED was emplaced nearby. Here, too, we used elaborate scripts to make civilians behave realistically.

Occasionally, we needed access to a variable or function that was not available to the scripting framework. For example, in VBS2, the HMMWV turret and gun are by default functionally fused; they rotate together as one entity. As a result, to look at something (e.g., a group of frolicking children), the trainee had to aim the .50-cal weapon at it. Not only was this an inaccurate simulation, but it delivered negative training—something we strove to avoid. There was no script available to force the turret and gun to move at all independently. We added a joystick to control the turret movement while the mock gun would control the aim. VBS2 was unable to register both the gun and the joystick as input devices unless we convinced it that the joystick was a mouse. We then discovered that VBS2 was reading the input from the gun and “mouse” at inconsistent speeds. After several attempts to fix this issue within VBS2, we were forced to query the “mouse” movement from the operating system rather than the game, and use that information as input for the turret movement. Again, with access to the source code, this problem could have been resolved in hours rather than weeks.

Of course, these situations are those in which our training requirements were outside the intended scope of VBS2. In the same situation, we would again select VBS2 for our development of a rapid prototype. However, to make a flexible simulation with fine control over its game elements, we would likely have selected a different engine.

Physical Environment

There were substantial limitations beyond VBS2—and even beyond the restrictive time-frame. First, confining the entire training system to four CONEX boxes proved uniquely challenging. The mock HMMWVs in CB4 took up a substantial amount of space—and rendered us unable to include a simulation of a dismounted patrol. This was a significant drawback; our SMEs emphasized in the CTA that dismounting (i.e., at geographical choke points) can be a critical element of IED defeat. They also, however, noted that when to dismount is often a matter of personal preference for a unit’s commander. We considered including a “dismount button” that would allow AI-controlled characters to sweep the area for IEDs, but decided that this solution provided too great an advantage for the BLUFOR. Eventually, we decided that the non-commissioned officers (NCOs; enlisted men and women at or above the rank of Corporal) who monitor the trainees could choose to discuss dismounting with the trainees—that the simulation in CB4 would be restricted to the practice of mounted patrol only.

The CONEX boxes had other limitations. For example, when the simulation was underway, VBS2 taxed the hardware of the computers in CB4, raising their temperature nearly high enough to boil water. There were 12 of these computers in the CB4—along with the 12 trainees, the NCOs, and the system operators. As a result, the standard air-conditioning systems were inadequate and several computers overheated. We had to add ventilation specifically for the computers as well as the large displays and custom air-conditioning units.

THE FUTURE

Despite the difficulties in development, MCIT is currently a functional training prototype. It has been vetted by our SMEs as well as a wide variety of military personnel, including previously deployed trainees (E1-E5, O1-2), experienced NCOs, and senior leadership up through the level of 3-star Generals. It has remarkable face validity in terms of its ability to provide basic instruction on the design, appearance, and deployment of IEDs; the mindset and motivation of the insurgent bomb-maker; and the procedures for identifying, avoiding, reporting, and defeating IEDs during mounted patrol. Trainees report that they better understand their adversaries and their adversaries' TTPs—and that they see IEDs as dangerous but not impossible to overcome.

Now that the process of developing the prototypes is complete, our focus has shifted to developing assessments of the learning promoted by MCIT. We have already been collecting and analyzing the data from quiz stations to determine what trainees are and are not learning from the videos and exhibits in CBs 1-3. We have also implemented a logging system in CB4 that records trainees' actions. This information will allow us to analyze the TTPs developed by trainees when they take the role of OPFOR, which may be able to inform real-world precautions in theater. We are working to refine a learner-management system that will allow us to link a trainee's quiz scores to his/her performance data in the simulation. This link will permit advanced analyses of trainees' MCIT experience and what they learned from it, which we will be able to use to further refine the training delivered by the system.

Finally, we are revising a pen-and-paper test of knowledge provided and practiced in MCIT. We have two goals with this survey. The first is to administer it as a pretest-posttest instrument to determine what is and is not being sufficiently conveyed and reinforced in MCIT. We will define training success as the magnitude of improvement from the pretest to the posttest. We also hope to be able to provide the posttest at a significant delay to see what information is retained at an educationally realistic interval; if improvements vanish after 20 minutes, we need to revise the experience.

Our second goal with this survey is to measure MCIT relative to the training approaches that preceded it (described above). For example, we could compare the improvement in test scores from pretest to posttest on MCIT versus on an IED walk. Alternatively, we could examine to what degree MCIT and an IED walk worked together to improve retention. That is, the greatest, most lasting gains might be promoted by using MCIT to supplement prior training approaches.

As we continue to explore and refine MCIT, we intend to rely on robust findings from cognitive psychology and instructional design, the latest technological advances, and the centuries-old practice of storytelling to make the experience as effective a training tool as possible. In our interactions with trainees, particularly those who had already been deployed, it was repeatedly made clear to us how important the counter-IED effort has become. To the extent that our work has reduced the loss of life and limb, we are proud—and determined to continue our efforts.

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REFERENCES

Anderson, L.W., & Krathwohl, D.R. (Eds.). (2001). *A taxonomy for learning, teaching, and assessing: A revision of Bloom's taxonomy of educational outcomes* (Complete ed.). New York: Longman.

Beilock, S.L., & Carr, T.H. (2001). On the fragility of skilled performance: What governs choking under pressure? *Journal of Experimental Psychology: General*, *130*, 701-725.

Bloom, B.S., & Krathwohl, D.R. (1956). *Taxonomy of educational objectives, handbook I: Cognitive domain*. New York: Longman.

Chao, C.J., & Salvendy, G. (1994). Percentage of procedural knowledge acquired as a function of the number of experts from whom knowledge is acquired for diagnosis, debugging and interpretation tasks. *International Journal of Human-Computer Interaction*, *6*, 221-233.

Clark, R.E., & Estes, F. (1996). Cognitive task analysis. *International Journal of Educational Research, 25,* 403-417.

Clark, R.E., Feldon, D.F., van Merriënboer, J.J.G, Yates, K., & Early, S. (2007). Cognitive task analysis. In J.M. Spector, M.D. Merrill, J.JG. van Merriënboer, & M.P. Driscoll (Eds.) *Handbook of Research on Educational Communications and Technology* (3rd ed.) (pp. 577-593). Mahwah, NJ: Erlbaum.

Evans, C., & Gibbons, N.J. (2006). The interactivity effect in multimedia learning. *Computers & Education, 49,* 1147-1160.

Galinsky, A.D., Maddux, W.W., Gilin, D., & White, J.B. (2008). Why it pays to get inside the head of your opponent: The differential effects of perspective-taking and empathy in negotiations. *Psychological Science, 19,* 378-384.

Kim, J., Hill, R.W., Durlach, P.J., Lane, H.C., Forbell, E., Core, M., Marsella, S., Pynadath, D., & Hart, J. (in press). BiLAT: A game-based environment for practicing negotiation in a cultural context. *International Journal of Artificial Intelligence in Education*.

Kirschner, P.A., Sweller, J., and Clark, R.E. (2006). Why minimal guidance during instruction does not work: An analysis of the failure of constructivist, discovery, problem-based, experiential, and inquiry-based teaching. *Educational Psychologist, 41,* 75-86.

Kornell, N., Hays, M.J., & Bjork, R.A. (2009). Unsuccessful retrieval attempts enhance subsequent learning. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 35,* 989-998.

Malone, T.W., & Lepper, M.R. (1987). Making learning fun: A taxonomy of intrinsic motivations for learning. In R.E. Snow & M.J. Farr (Eds.), *Aptitude, Learning, and Instruction,* Vol. 3 (pp. 223-253). Hillsdale NJ: Erlbaum

Mayer, R. (2004). Should there be a three-strikes rule against pure discovery learning? The case for guided methods of instruction. *American Psychologist, 59,* 14-19.

McAlinden, R., Gordon, A., Lane, H.C., & Pynadath, D. (2009). UrbanSim: A game-based simulation for counterinsurgency and stability-focused operations. *Proceedings of the Workshop on Educational Games at the 14th International Conference on AI in Education*, 41-50.

Morris, C.D., Bransford, J.D., & Franks, J.J. (1977). Levels of processing versus transfer appropriate processing. *Journal of Verbal Learning and Verbal Behavior, 16,* 519-533.

Roediger, H.L., & Karpicke, J.D. (2006). Test-enhanced learning: Taking memory tests improves long-term retention. *Psychological Science, 17,* 249-255.

Schmidt, R.A., & Bjork, R.A. (1992). New conceptualizations of practice: Common principles in three paradigms suggest new concepts for training. *Psychological Science, 3,* 207-217.

Schwartz, D.L., & Bransford, J.D. (1998). A time for telling. *Cognition and Instruction, 16,* 475-522.

Singer, R.N. (1968). *Motor Learning and Human Performance.* New York: Macmillan.

Vogel, J.J., Vogel, D.S., Cannon-Bowers, C.A., Muse, K., & Wright, M. (2006). Computer gaming and interactive simulations for learning: A meta-analysis. *Journal of Educational Computing Research, 34,* 229-243.