Cognitive Training Transfer Using A Personal Computer-based Game:a Close Quarters Battle Case Study

Michael Woodman
University of Central Florida

COGNITIVE TRAINING TRANSFER USING A PERSONAL COMPUTER-BASED GAME: A CLOSE QUARTERS BATTLE CASE STUDY

by

MICHAEL D. WOODMAN
B.A. University of California at Los Angeles, 1978
M.A. Webster University, 1993

A dissertation submitted in partial fulfillment of the requirements
for the degree of Doctor of Philosophy
in the Department of Industrial Engineering and Management Systems
in the College of Engineering and Computer Science
at the University of Central Florida
Orlando, Florida

Spring Term
2006

Major Professor: Michael D. Proctor

ABSTRACT

Developers of Commercial off the Shelf (COTS) gaming software are making remarkable strides in increasing the realism of their software. This realism has caught the attention of the training community, which has traditionally sought system and operational replication in training systems such as flight simulators. Since games are designed and marketed for entertainment and not designed for training of tasks, questions exist about the effectiveness of games as a training system in achieving the desired transfer of skills to the actual environment. Numerous studies over the past ten years have documented that PC-based simulation training environments can offer effective training for certain types of training, especially aircraft piloting tasks. Desktop games have been evaluated from a case study approach for use in aviation training (Proctor, et al., 2004) and education planning and evaluating small unit tactics) (Proctor, et al., 2002) with positive results.

Based on the review of selected studies in this area, PC-based simulator platforms have been found to have a positive training impact on cognitive skills (as opposed to psycho-motor skills). Specifically, the literature review has identified that skill sets involved in team resource management, intra- and inter-team coordination, and tactical team maneuvers have been shown to benefit from the use of PC-based simulation training.

The purpose of this research was to evaluate the training transfer associated with a Tactical Decision-making game, using *Close Combat: First to Fight* as a case study. The null hypothesis tested was that traditional field training is equivalent to virtual training combined with field training. Measurements of the subjects' performance in live training were recorded. Additionally, self assessment questionnaires were administered.

This dissertation is dedicated to my wife, Michele, and my daughters, Shawna, Danielle, Kristen, and Kimberly. Thanks for your patience, support, and understanding!

ACKNOWLEDGMENTS

Any effort of this magnitude is impossible without extraordinary support. For that, I wish to thank my entire committee, Dr. Linda Malone, Dr. Peter Kincaid, Dr. Charles Reilly, Dr. Elizabeth Biddle, and particularly my advisor and advocate, Dr. Michael Proctor.

I must also acknowledge the assistance of the students and instructors at the Marine Corps Security Force Training Company in Chesapeake, Virginia. Without their “gung ho” attitude, flexibility, and dedication, this experiment could never have been accomplished. Thanks in particular to Captain Peter Young, USMC for your support. Semper Fidelis!

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF ACRONYMS/ABBREVIATIONS

AI	Artificial Intelligence
Bn	Battalion
CQB	Close Quarters Battle
CO	Commanding Officer
COTS	Commercial off the Shelf
DSB	Defense Science Board
DVTE	Deployable Virtual Training Environment
DIVE	Dismounted Infantry Virtual Environment
EBAT	Events Based Approach to Training
F2F	Close Combat: First to Fight
FTCST	Fire Team Cognitive Skills Trainer
HUTS	Hostages, Unidentified, Terrorists, and Shooters
IAW	In Accordance With
ITS	Individual Training Standards
KSA	Knowledge, Skills, and Abilities
LOI	Letter of Instruction
MCSF	Marine Corps Security Force
MCWL	Marine Corps Warfighting Lab
MEU(SOC)	Marine Expeditionary Unit (Special Operations Capable)
MOUT	Military Operations on Urban Terrain
NDM	Naturalistic Decision Making
NATO	North Atlantic Treaty Organization

OBT	Objective Based Training
O/C	Observer/Controller
O&M	Operation and Maintenance
Ops/Eval	Operations Evaluation
OpFor	Opposing Force
PC	Personal Computer
PFT	Physical Fitness Test
PFC	Private First Class
ROTC	Reserve Officer Training Corps
RPG	Roll Playing Game
SA	Situational Awareness
SME	Subject Matter Expert
TDS	Tactical Decision-making Simulation
TTP	Tactics, Techniques, and Procedures
T&R	Training and Readiness
USMC	United States Marine Corps
USMA	United States Military Academy
VISE	Virtual Infantry Section Experiment

CHAPTER 1: INTRODUCTION

Developers of Commercial off the Shelf (COTS) game software are making remarkable strides in increasing the realism of their software. This realism has caught the attention of the training community, which has traditionally sought system and operational replication in training systems such as flight simulators. Yet questions exist about the effectiveness of games as training systems in achieving the desired transfer of skills to the actual environment. Using a case study approach, this research will explore these questions.

The U.S. Navy and Marine Corps (USMC) have placed a great emphasis on training Sailors and Marines in virtual environments. In particular, a suite of Tactical Decision-making Simulations (TDS), most developed under the Office of Naval Research and transitioned to the Deployable Virtual Training Environment (DVTE), is comprised of wargames using synthetic environments. The wargames incorporated into DVTE include *Close Combat: Marine* from Atomic Games, *Tactical Operations Marine Corps* by I.L. Holdridge, *Virtual Battlefield Systems* from Bohemia Interactive Studio, *Forward Observer Personal Computer Simulation* from the Naval Postgraduate School, *Ambush!* from BBN Technologies, *Close Combat: First to Fight* from Destineer Studios, Logistics TDS from Technologies To Be, Inc., and *MAGTF-XXI* from MÄK Technologies. Soon to be added are an Anti-Terrorism TDS and a Joint Terminal Attack Controller TDS, both from Destineer Studios.

While few would argue that games or other personal computer (PC)-based training systems could replace existing field training, the TDSs can provide the opportunity to improve a Small Unit Leader's level of knowledge, decision-making ability, and communication skills within his team in order to prepare for and to augment live training. This is a relatively inexpensive solution that will provide a new training capability to the USMC. The purpose of this research is to evaluate the training transfer associated with this type of game, using one TDS as a case study. Rigorous experimentation measures the subjects' improvement in cognition when confronted with decision-making tasks. This experimentation will compare, assess, and report on training value achieved through traditional field training versus the benefits of virtual training combined with field training.

Current demographic trends indicate that during the 21st century, an ever-increasing percentage of the world's population will reside in urban areas. The USMC has identified the potential for conflict in urban areas and is attempting to rectify its deficiencies in this arena. "We have been working diligently to ensure that we can fight the three-block war, because we believe in our heart and souls that that is the conflict of the 21st century." (Krulak, 1999) The current focus of the Marine Corps Warfighting Laboratory's (MCWL) experiments is to develop tactics, techniques, and procedures that can reduce the casualty percentage below 30% in the urban environment. "The urban environment is the most-likely battlefield in the near future. Developing means to deal with this unique environment is essential." (MCWL, 2001) The 30% percent casualty rate is a number that, historically, has rendered a unit ineffective in combat.

> Daily rates of casualty and illness incidence sustained in the re-taking of the city of Hue during the North Vietnamese Tet offensive of 1968 were examined. The daily wounded rate for the U.S. Marine battalions involved was 17.5 per 1,000 strength, and ranged from 1.6 to 45.5. The killed-in-action rate per 1,000 strength per day was 2.2, and ranged from 0.0 to 9.6. The wounded rate during the urban warfare of Hue was three times higher than during the high intensity battle for Okinawa and sixfold the wounded rate during normal Marine operations at the peak of the Vietnam conflict. The disease and non-battle injury rate remained steady over the course of the Hue operation at approximately 1.0 per 1,000 strength per day. (Department of the Navy, 2000)

Because of the compartmental terrain of the urban environment, Military Operations on Urban Terrain (MOUT) truly becomes a small unit's battle. The decisions of the small unit leader have the potential to create strategic consequences for the U. S. military in the region. This logic led then-Commandant of the Marine Corps General Charles Krulak to coin the term "strategic corporal: The individual who at the very lowest level of the Marine Corps is going to have to deal with issues of strategic importance." (Krulak, 1999)

Any leader's ability to make competent decisions is derived from two major factors: how well he has been trained and educated and how much experience he has with a particular situation. The typical USMC squad leader is a corporal with less than four years in the service (even though the USMC Table of Organization calls for a sergeant). His formal education generally is limited to high school and his training has consisted of recruit training and the basic infantry skills learned at the Infantry Training Battalion. He most likely has no experience leading a small unit, particularly in a MOUT environment.

Most Marine Corps infantry training today is focused on the Infantry Battalion or Battalion Landing Team (as part of a Marine Expeditionary Unit (Special Operations Capable) (MEU(SOC))). As the building blocks of the battalion, Infantry Companies are trained for particular aspects of combat—one company for mechanized operations, one company for helicopterborne operations, and one company for special operations such as in-extremis hostage rescue, tactical recovery of aircraft and personnel, and non-combatant evacuation.

As a result, while the battalion and company staffs are training for these missions and learning to conduct planning and write operation orders, the fire teams and squads are conducting field days; pulling mess duty; performing preventive maintenance on weapons, vehicles, and equipment; and going to the rifle range for annual requalification. Those few who are lucky enough to attend the training "represent" squads or even platoons. The impact, as one could guess, is that there is a gap in training at the lowest levels of the organization. When fire teams and squads do go to the field for training, the learning curve is so steep that they cannot take full advantage of the training opportunities.

Individual combatants and small teams want – and need – to be active participants in the fight. Soldiers at the point-of-the-spear *do* things – not just talk about them. At this level, warfighting systems run on functional objects, rather than sophisticated comments. The training immersion does not need to be total sensory. In fact, it may be only mental immersion. Thus, the current approaches of using simulation immersion caves and other enclosures may not be the answer. (Cosby & Severinghaus, 2003)

While the company commanders and platoon commanders are responsible for the training and preparedness of their units, the training task ultimately falls to the squad leaders and fire team leaders to ensure that their Marines are ready. The squad leaders and fire team leaders need a training system to assist them in preparing their Marines so that when field training is available, they can take the greatest advantage of it. Further, while these units are deployed aboard ship as part of a MEU(SOC), they need a tool to keep the Marines' skills refreshed as they tend to atrophy during long deployments at sea. As stated in the 2001 Report of the Defense Science Board (DSB) Task Force on Training Superiority & Training Surprise, "Future training must be delivered to the individual, to units, and to joint forces, when it is needed, not in the schoolhouse after which there is time for proficiency to decay. Training must be applied over and over again as the composition of the units and joint forces changes and as skills erode over time." (DSB 2001)

Time is a major constraint on the training of infantry squads and fire teams. What little time is available for training must be optimized. Further, a training system that is so enjoyed by the Marines that they would use their off-duty hours to take advantage of it, would supplement the training hours available.

The other major constraint on any infantry training system (in fact, any USMC training system) is cost. The USMC receives only about six per cent of the Department of Defense's budget, yet has the highest operational tempo of any service. This translates to very little funding available for training systems. Therefore, the training system selected must be extremely cost effective.

> Acquisition cost and hardware costs are the least important factor when considering acquiring or developing a simulation; unless, of course, a simulation requires a Cray computer. Operation and Maintenance (O&M) are the real costs associated with using a combat simulation. If a combat simulation requires a host of analysts, data base managers, war gamers, controllers, or programmers to make it work, it will not be cost effective. Cost effectiveness is closely related to the architecture, which in turn drives the ease of use and ease of modification. Interactive war games that require 25 to 100 players will not be used often enough to make them cost effective. (Might, 1993)

> Advanced modeling and simulations for games, entertainment, manufacturing, education, the U.S. Department of Defense, finance, and other applications will grow with the development of integrated media systems incorporating software and hardware development at many levels. Integrated media systems will powerfully impact all fields of inquiry and technology. Integrated media systems of the future will seamlessly combine digital video, digital audio, computer animation, text, and graphics into common displays in such a way as to allow for mixed media creation, dissemination, and interactive access in real time. (Gundersen, 1997)

While M. Gundersen's point is well taken and, in fact, is good news for both the civilian and military communities, it in no way detracts from the long-term viability of the technology proposed for the Fire Team Cognitive Skills Trainer. Technology advances will continue to speed along (just ask anybody who buys a new computer—by the time the system is out of the box and set up, something new and faster is available!). However, the technology proposed here satisfies not only the requirements for the training system today but well into the future.

Operation and Maintenance costs are minimal. As COTS systems, the hardware is covered for three years by the manufacturer's warranty and the software has manufacturer's support available. The cognitive skills that will be addressed by the system will remain the same regardless of technological advances in computer systems or even in the weapons to be used by the Marines. "Technology is not a panacea. Technology cannot – and will not – replace the Marine staples of resolute leadership, esprit-de-corps and skill-at-arms that have won battles for more than 200 years." (MCWL, 2001)

The urgency of the foregoing, combined with the minimal amount of funding available to provide this training, points out the need for a readily available, easily modifiable, COTS solution to training the strategic corporal and his Marines. One possible answer is PC-based commercial, "first-person shooter" wargames.

While there are numerous references available discussing simulations and wargaming, precious little addresses small unit training and the validation of training transfer. For example, War Gaming: In Need of Context (Schwalbe, 1993) discusses conflict in Central Europe involving the North Atlantic Treaty Organization (NATO) and the Warsaw Pact, The Korean Peninsula, the Middle East/Persian Gulf, The Balkan Peninsula, and Eastern Europe. Current Applications, Trends, and Organizations in U.S. Military Simulation and Gaming (Oswalt, 1993) talks about Janus, Brigade/ Battalion Simulation, Warfighters' Simulation 2000, Combined Arms Tactical Training [Army], Joint Air Combat Training System [Air Force], Battle Force Team/Tactical Training System [Navy], and WAR BREAKER [Defense Advanced Research Projects Agency]. Even Military Simulation and Gaming Organizations (Oswalt, 1993) lists producers of commercial military simulations for hobbyists that bear names such as *F-16 Combat Pilot*, *M-1 Tank Platoon*, and *Carriers at War*.

Although Principles for the Design and Selection of Combat Simulations (Might, 1993) is also directed at higher levels of simulations, the principles listed may be entirely applicable to selecting a small unit simulation as well:

1. Architecture—a simulation must be flexible as user needs change, and its structure must allow cost effective use and maintenance;
2. User needs—what the simulation is to be used for and how it is to be used;
3. Integration—how the simulation will interface with other simulations that are relevant to the user, and other models that may potentially interface with the simulation.

The PC gaming and simulation industry, largely driven by recent technology advances and consumer economics, has dramatically driven cost down while improving the quality and realism of games and desktop simulation technologies. Just nine years ago, computer simulation games and simulations were judged to be low on fidelity, interface, and immersion dimensions (Thurman & Matoon, 1994). Compared to the games of today, they could not faithfully represent the real world nor did they have very natural interfaces, and the feeling of being immersed in the simulation was accomplished only through imagination. All that has changed with the significant strides we have seen in the development of graphics and animation software, artificial intelligence, computer interfaces, and networking.

The most noticeable advances in PC games have come in the area of computer graphics. “Images on today’s $400 game consoles rival or surpass those on $50,000 computers from only a few years ago (Laird, 2000).”Realistic images combined with more realistic controls allow the participant to feel, through multiple senses, the feeling of “being there.” In the future, virtual reality technology will expand gaming to include “the participant’s entire body within a synthetic environment rather than simply providing a joystick or other external interface device as today's computer games do." (Thurman & Matoon, 1994)

Just as graphics and computer interface advances have produced more realistic simulations of the physical world, artificial intelligence (AI) is resulting in more realistic modeling of game characters. Artificial intelligence at the human level can be applied to tactical enemies, partners, support characters, and even units of individuals, such as platoons (Laird & van Lent, 1999). As AI research progresses, game characters will possess qualities that are increasingly more human-like. Even now, AI researchers at the University of Michigan have created an enemy "bot" for the *Quake II* game that is essentially a real-time expert system that has multiple goals and extensive tactics and knowledge of the game. The *Quake II* bot tries to anticipate the actions of the human players, tracks down its enemy, and sets ambushes (van Lent, et al., 1999).

Several studies have suggested that PC simulation games can produce transfer of cognitive skills that have application to a wide variety of domain-specific tasks. In fact, several PC games have been found to be advantageous for conducting psychological research in the cognitive processes involved in problem-solving (Porter, 1998), strategy development (Gonzales & Cathcart, 1995), and changes in neural maps (Tallal, et al., 1996).

CHAPTER 2: LITERATURE REVIEW

Because of the nature of the military application area as well as the diverse nature of gaming systems, consideration of both military and gaming system literature is appropriate.

Some members of the education community question the conclusion that games can be directly applied to training tasks with a positive effect. For example, McCarty explored gaming environments to assess learning activities in computer games. He found that his subjects, during their gaming playing, did not learn anything in depth about the underlying model of the game. Their clicking and exploring of the game was kept on the surface level.

> Simulations appear to be of little educational value if the model cannot be accessed. This argues for close teacher direction if the use of the simulation in history is to be educationally valid on terms of measurable 'knowledge' outcomes. From this research, computer games in general do not appear to offer a pedagogic environment. The focus for the player is to play and win the game—the research subjects were concerned to know 'how to win'. The notion of learning whilst playing was never explicit or implicit in anything the students said. (McCarty, 2001)

His research suggests that game play is a distraction from learning and that games do not necessarily teach the knowledge that is actually embedded in the models themselves.

Greenfield, a professor of psychology at the University of California at Los Angeles, has studied the effects of video games on players' minds. She believes that video games may be the first example of a computer technology that is having a socializing effect on a generation and that individuals seem to be developing better iconic representation skills than the person who was socialized by the older media of print and radio. Among her findings in this research and subsequent research in 1996, "Video game skills transfer to and lead to greater comprehension of scientific simulations, due to increased ability to decode the iconic representation of computer graphics (Greenfield, 1984)". Also among Greenfield's findings are:

- Playing video games augments skill in reading visual images as representations of three-dimensional space (representational competence). This is a combination of several competencies, including partnering with the computer in the construction of the representation, using the joystick (or other controller) as a "distanced" representational tool, working in real-time, multidimensional visual-spatial skills, and mental maps.
- Skill in computer games enhances, and is a causal factor in, other thinking skills such as the skill of mental paper folding (i.e. picturing the results of various origami-like folds in your mind without actually doing them.). What is important, she finds, is this is a *cumulative* skill—there is no effect on mental paper folding from playing the game for only a few hours. These effects were found in other studies as well.
- Because no one tells you the rules in advance, video games enhance the skills of "rule discovery" through observation, trial and error, and hypothesis testing. In Greenfield's words, "the process of making observations, formulating hypotheses and figuring out the rules governing the behavior of a dynamic representation is basically the cognitive process of *inductive discovery* … the thought process behind scientific thinking." Computer games, she finds, require this skill.
- Video game skills transfer to and lead to greater comprehension of scientific simulations, due to increased ability to decode the iconic representation of computer graphics.

- Playing video games enhances players' skills at "divided attention" tasks, such as monitoring multiple locations simultaneously, by helping them appropriately adjust their "strategies of attentional deployment." Players get faster at responding to both expected and unexpected stimuli. (Prensky, 2001)

Pillay, Brownlee, and Wilss (1999), noticing that recreational computer games are becoming an increasingly significant part of students' lives, conducted an exploratory study aimed at understanding the cognitive processes that students engage in when playing computer games. Using Nintendo's *Pilot Wings*, they demonstrated that players practiced "complex cognitive processes such as interpreting explicit and implicit information, inductive reasoning, metacognitive analysis, and problem solving." They went on to say that PC games have been shown to enhance soldiers' decision-making skills through practice with variation.

Homan (1998) proposed that low cost, low fidelity PC aviation simulations could be used to enhance pilots' situational awareness (SA). SA is the process the pilot uses to maintain a "continuously updated mental picture of the flight at hand." Homan suggested that various scenarios in PC simulations could assist the pilot in identifying and handling unusual situations by training the pilot to be aware of clues in the situation.

Several recent experiments may enable one to draw some conclusions regarding the value of PC-based games for cognitive transfer.

1. <u>Interoperable Training through a Simulation Game (Proctor, et al., 2002)</u>

Thirteen Reserve Officer Training Corps (ROTC) cadets conducted training using *Combat Mission: Beyond Overlord*™. Each cadet completed a 43-question survey after training. The "cadets indicated in a statistically significant degree (Wilcoxon sign test) a number of advantages to the game." Further, the cadets indicated "that using this commercial-off-the-shelf software is a viable, low-cost option for training tactical concepts at the platoon and company level. Specifically, cadets indicated the game system would be beneficial 'for teaching and practicing tactical concepts and troop-leading procedures to Basic Course officers at a combat-arms branch school.'"

2. Low Cost PC-Gaming and Simulation Research: Doctrinal Survey (Tarr, Morris, and Singer, 2002)

Tarr, et al., conducted a focus group type of evaluation with Subject Matter Experts (SME) to determine the doctrinal correctness of two PC games with potential for use in training. One of these, *Rogue Spear: Covert Ops*™, could be used for training, according to the SMEs, "in spite of the doctrinal problems, as long as trainers attended to those negative aspects present in the training vignette." Furthermore, the "SMEs were open to using the game in an early training stage for new troops."

3. Factors in Team Performance in a Virtual Squad Environment (Barlow, et al., 2004)

An experiment was conducted to explore the use of a first person shooter, *Operation Flashpoint*™, in a competitive team environment and to determine the factors that correlate to the success or failure of a team. Among the factors considered was whether the participants used Naturalistic Decision Making (NDM) or a heuristic process. ("NDM is a theory about the way humans make decisions under the constraints of incomplete knowledge, time pressures, a dynamic environment, and high costs for errors; and appears to encapsulate many situations faced by a military commander.")

The experiment was conducted as a competition at the Australian Defence Force Academy. Eight teams competed, five teams of officer cadets and midshipmen, two teams of officers taking undergraduate courses, and one team of staff civilians. At the conclusion of the match, each individual was asked to rate five factors on a scale from 1 (not significant) to 10 (most significant) that had been important to team victory during the matches. "Team communication was seen as the most important (9.3) with individual skills, and situational awareness also being rated as very important (8.0 – 8.3)."

The results of the players' situational awareness show the rarity of complete knowledge of the disposition of friendly forces and even less knowledge of the enemy. This lack of complete situational awareness, combined with the participants' perception of a very rapid pace of action and the high cost of mistakes "describe the key conditions of an NDM environment. When this is combined with the data regarding the decision-making processes of the participants – the strong use of intuition as well as assigned roles to reduce the complexity – the proposition that a [first person shooter] is a good vehicle for the investigation of NDM theory, seems well founded."

4. <u>Child's Play? Coercing a COTS Game into a Military Experimentation Tool (Morrison & Barlow, 2004)</u>

Focused on experimentation, the Virtual Infantry Section Experiment (VISE) evaluated possible future force structures in the Australian Army but also explored the potential of *Virtual Battlefield Systems*™ as a tactical training system. This experiment determined, through survey responses, that *Virtual Battlefield Systems*™ appeared to be a good tool for the utility of the two-dimensional map for tactical appreciation, for representing section scenarios, for tactical training potential, and for teamwork and subunit training. Some valuable recommendations as a result of the experiment were:

- “Optimum COTS games for Defence are modifiable, extendable products that naturally support customisation. Mandatory features include a scenario editor, the ability to modify aspects of the simulation engine (typically the look and performance of game entities and weapons), and the ability to import custom terrain and vegetation.”
- “Training outcomes and methodology must be developed before the implementation of a product.”
- “Directing staff (preferably military) are an essential requirement when conducting training of Defence personnel in a COTS simulation.”

5. <u>Dismounted Infantry Virtual Environment (DIVE) (Henegan, 2005)</u>

“Trials, conducted by the Ministry of Defence and the defence technology company QinetiQ, found that soldiers who had played urban war games on computers were less likely to suffer casualties and completed tasks quicker during live exercises.”

6. <u>Commercial Computer Games in the Australian Department of Defence (Carpenter & White, 2005)</u>

The University of New South Wales conducted a literature review and evaluation of commercial games on behalf of the Australian Defence Simulation Office. “With due caution we are therefore formally opening the door for commercial computer games to be considered as potential contributors to the Defence simulation arena. We see the many benefits while recognising the current risks and limitations that such products have to offer.”

While these articles provide encouragement for using simulations for cognitive skill learning, none of them show any evidence that the general cognitive skills taught in the simulation generalized to other domains or situations. Nor do they give us criteria for or taxonomy of computer games as they relate to systems for training. Thurman and Dunlap (2000), in their review of military and commercial applications of simulation training, point out the paucity of data related to the training effectiveness of simulations and lack of data on specific transfer of training. They suggest, however, that this state of affairs may be explained by the movement toward new models of training evaluation, models that emphasize general transfer of skills that give the trainee the ability to generalize and respond to situations that do not exactly match those for which they were trained.

Taxonomies

Before computer games, Caillois divided games in to four classes: Competition, Chance, Simulation, and Movement (Caillois, 1958). In his book, Crawford identified five major types of games: board games, card games, athletic games, children's games, and computer games (Crawford, 1984). Amory et al. (1998) used four commercial games representing four game types (simulation, adventure, strategy, and "shoot-em-up") to examine the game types most suitable for teaching biology. First- and second-year biology students preferred the adventure and strategy games to the other game types and reported that, in their opinion, logic, memory, visualization, and problem solving were the most important skills used in these games. The authors suggested a model for the design of educational games based on the game elements described in their study. Since the turn of the Millennium, computer games are generally categorized into eight genres:

> **Action Games** began with the classic "twitch" games of the arcades and home video consoles: *Super Mario, Sonic the Hedgehog* et al. The category includes the old "side scroller" games, maze games (*PacMan*), platform jumping games (e.g. *Gekko*), falling things you have to shoot (*Missile Command*), car races and chases. Obviously this is the category of the shoot-em-ups like *Doom, Quake, Duke Nukem, Half-Life and Unreal Tournament.*
>
> **Adventure Games** are the "find your way around the unknown world, pick up objects and solve puzzles" games. These are among the earliest of computer

games; *Adventure* was played on mainframes. *Zork* is a classic of the genre. Present day adventure games include *Myst* and *Riven* on the PC and *Zelda*, *the Ocarina of Time* on Nintendo

Fighting Games are a lot of what you see in the lobbies of movie theaters. Two characters, drawn from a stable of hundreds, battle each other till one is wiped out. All these games are really doing is matching up two "moves" at the same time, to see which wins., But the speed is intense, and the moves are athletic, balletic and fantastical. They are typically captured by motion capture sensors on dancers and real martial arts fighters, and the goal appears to be to combine outlandish fantasy in the characters with realism of the computer graphics. The classic example: *Mortal Kombat*. Modern example: *Virtua Fighter MMMCIII.*

Puzzle games are just that. Problems to be solved, typically visual, stripped of all story pretense. The classic example: *Tetris*. Modern example: *Devil Dice*

Role Playing Games (RPGs) are generally some form of "Dungeons and Dragons" brought to the computer screen. They are mostly mediaeval in their imagery and involve quests usually to rescue someone or something. You play a character, which has a "type" (human, orc, elf, wizard, etc) and a set of individual characteristics you assign it. You acquire equipment and experience via action and fighting. Things like spells are a big deal. The classic example: the *Ultima* series. Modern example: *EverQuest*. RPGs are most often played online with others.

Simulation Games are about flying or driving things (often military) or building worlds like *Sim City* and *The Sims,* or, increasingly, running companies (*Start-up*)

Sports Games are the one category where the content, rather than the game play is the determining factor. Most are action games where you can control one or more players at a time. Sports games are getting so photorealistic that on the latest consoles you'd almost swear you were watching real players on television. There also exist less action- and more statistics-oriented sports games like fantasy baseball, as well as action sports games, especially in arcades, where you control the game via a realistic piece of sports equipment such as skis, a surfboard, or even — only in Japan — a rotating kayak paddle.

Strategy games are typically about being in charge of something big – an army, or an entire civilization, and making it evolve the way you want, either on your own or more often against opponents. The classic example: *Civilization*. Modern example: *Roller Coaster Tycoon*. (Prensky, 2001)

Numerous studies over the past ten years have documented that PC-based simulation training environments can offer effective training for certain types of training, especially aircraft piloting tasks. Based on the review of selected studies in this area, PC-based simulator platforms have been found to have a positive training impact on cognitive skills (as opposed to psycho-motor skills). Specifically, the literature review has identified that skill sets involved in team resource management, intra- and inter-team coordination, and tactical team maneuvers have been shown to benefit from the use of PC-based simulation training. In addition, some researchers have indicated that the use of PC-based training can increase the confidence level of students (Rantz, 1998).

Many taxonomies exist for organizational behaviors. Of the several reviewed, only three, “Use of networked simulations as a context to measure team competencies,” “Structure and Process Organizational Taxonomy (SPOT),” and “A Basic Classification Structure” fit the topic of Military Team Performance for the size of team that I am evaluating.

> Currently available taxonomies of organizational behavior are not uniformly clear as to the unit of analysis that is being used (i.e., is the analysis being conducted in terms of individuals, teams/groups, and/or units/organizations). Some taxonomies include concepts that are clearly transferable from one unit of analysis to another (e.g., Miller, 1965a, 1965b, 1965c). Others clearly differentiate the unit of analysis but are not completely clear about the distinctions between levels of abstraction (i.e., specification in terms of behavior or function (e.g., Indik, 1968; Indik & Berrien, 1963). Still others provide useful insight into important types of organizational “variables” with no clear description of how these variables are realized in individuals, teams/groups, and/or units/organizations (e.g., Baudhuin, 1985; Sells, 1968). (Cameron & Urzi, 1999)

In my experimentation I will be focusing on the Marine Corps Fire Team and Squad level. The composition of a standard Marine Corps Squad is as shown in Figure 1:

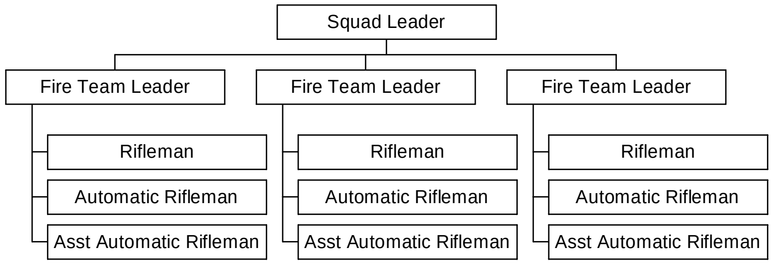

Figure 1: Composition of a Marine Corps Rifle Squad

Table 1, adapted from "Taxonomies of Organizational Behaviors: A Synthesis" (Cameron & Urzi, 1999), demonstrates the relationships between the taxonomy that I propose to use and the three taxonomies mentioned above that fit the topic of Military Team Performance for the size of team that I am evaluating.

Table 1
Relationships between Taxonomies for Military Team Performance

O'Neil, et al.	Appel, et al.	Indik	Woodman
Communication	Communication	Communication	Communication
	Control	Control	Control
Coordination	Coordination	Coordination	Coordination
Interpersonal	Socialization/Integration	Group socialization-integration processes	Cooperation
Decision Making	Managership	Supervision	Cognition
Leadership	Leadership		Command
Adaptability	Degree of flux	Adaptability to change	(Coordination)
	Conflict control processes	Conflict control process	(Command, Cooperation)
	Role specification	Mutual understanding of reciprocal role relations	(Command, Cooperation)
	Degree of bureaucracy	Degree of bureaucracy	(Command)
	Natural environmental conditions		(Command, Cooperation)
	Availability of needed resources		(Command, Cooperation)
	Relations with social environment	Amount of communication interaction of members of the group with non members for organizational purposes	(Communication)
		Distribution of communication interaction by members of the group with non members for organizational purposes	(Communication)
	Externally imposed change		(Command, Cooperation)

> To measure teamwork processes, we used the taxonomy of teamwork process from prior work. The taxonomy has six teamwork processes: (a) adaptability, recognizing problems and responding appropriately; (b) communication, the exchange of clear and accurate information; (c) coordination, organizing team activities to complete a task on time; (d) decision-making, using available information to make decisions; (e) interpersonal, interacting cooperatively with other team members; and (f) leadership, providing structure and direction for the team. Our prior research showed statistically significant positive relationships between decision making and team performance on a negotiation task (final contract offer and negotiation style), and a significant negative correlation between interpersonal processes and whether an agreement was reached. (O'Neil et al., 1997)

As I have proposed, training at the military squad and fire team level must focus on the team performance behaviors of command, control, communications, coordination, cooperation, and cognition.

- The squad leader and fire team leaders need to be able to:
  - <u>Command</u> the squad or fire team through the use of clear, concise operation orders.
  - <u>Control</u> the movements and actions of the fire teams or individuals, both verbally and non-verbally.
  - <u>Coordinate</u> the efforts of the fire teams or individuals. (Another aspect of coordination is developing and maintaining shared mental models, which applies to all members of the group to enable adaptability.)
- All members of the group must be able to:
  - use their powers of <u>cognition</u> (decision-making) to accomplish the mission.
  - <u>Communicate</u> distinctly and succinctly up and down the chain of command and with one another.

- <u>Cooperate</u> with one another to maximize the combat power of their combined numbers (the holistic factor), as well as to share resources and control internal conflict.

Table 2 shows the relationships between these team performance behaviors that appear to have potential for training via computer games and the game genres listed above.

Table 2
Relationships between Computer Game Genres and the Military Team Performance Behaviors

Training / Games	Command	Control	Communication	Coordination	Cooperation	Cognition
Action (Multiplayer)	X	X	X	X	X	X
Adventure	X	X				
Fighting						
Puzzle						X
Role Playing	X	X	X	X	X	X
Simulation			X	X	X	X
Sports		X	X	X	X	
Strategy	X	X				X
X = Team performance behaviors that appear to have potential for training via the computer game genre indicated						

<u>Team Competencies</u>

Aside from taxonomies, "team competencies (knowledge, skills, and abilities--KSAs) are vital to understanding and evaluating team performance in dynamic environments" (Cannon-Bowers & Salas, 1998). More recently, "Salas and Cannon-Bowers (2000) summarized teamwork dimensions into three primary categories: cognitions, skills and attitudes. Cognitions (or knowledge) include cue strategy associations, task specific team-mate characteristics, shared task models, team mission, objectives, norms, and resources, task sequencing, accurate task models and problem models, team role interaction patterns, teamwork skills, boundary spanning roles, and team orientation. Behaviours (or skills) consist of adaptability, shared situational awareness, mutual performance monitoring, motivating team members/team leadership, mission analysis, communication, decision-making, assertiveness, interpersonal coordination, and conflict resolution. Last, attitudes embody motivation, collective efficacy/potency, shared vision, team cohesion, mutual trust, collective orientation and importance of teamwork” (Paris, Salas, & Cannon-Bowers, 2000). And, according to Ioerger, “Team competencies are those requirements that are needed for effective team performance. Team competencies can be divided into: knowledge, skills, and attitudes. Knowledge refers to factual information about the domain, mission, and team structure that team members must know in order to interact effectively. For example, they need to know who plays what role, and what the capabilities of their teammates are. Skills refer to the teamwork processes, such as information exchange, load balancing, and conflict resolution. And attitudes refer to the motivational determinants of team members’ choices, such as orientation toward teamwork, leadership, and willingness to accept advice or help” (Ioerger, 2003). Table 3 provides a summary:

Table 3
Team Competencies

Knowledge/Cognition	cue strategy associations task specific team-mate characteristics shared task models team mission, objectives, norms, and resources task sequencing accurate task models and problem models team role interaction patterns teamwork skills boundary spanning roles team orientation factual information about the domain factual information about the mission factual information about the team structure
Skills/Behaviors	adaptability shared situational awareness mutual performance monitoring motivating team members/team leadership mission analysis communication decision-making assertiveness interpersonal coordination conflict resolution information exchange load balancing
Attitudes/Abilities	motivation collective efficacy/potency shared vision team cohesion mutual trust collective orientation and importance of teamwork leadership willingness to accept advice or help

Training Teams in Virtual Environments

As mentioned earlier, the U.S. Navy and USMC have placed a great emphasis on training Sailors and Marines in virtual environments. “Successful problem solving performance in this environment requires the integration of multiple knowledge formats and, thus, mimics more complex operational team tasks. For example, trainees have to master, not only declarative knowledge (e.g. range and power of their assets) and procedural knowledge (e.g. how to launch an asset or attack an enemy target), but also what we label strategic knowledge (i.e. how to apply knowledge) and integrative knowledge (i.e. the ability to use multiple task-relevant cues to interpret a situation and choose an optimal strategy)" (Fiore, et al., 2002).

In "Distributed coordination space: toward a theory of distributed team process and performance," Fiore, et al. discuss "the many issues surrounding distributed team performance, emphasizing how work characteristics associated with such teams may alter both the processes and the products emerging from distributed interaction. (Fiore, et al., 2003). While the focus of the article is teams whose members are physically distributed and are using "technology-mediated communication" to interact, many of the points brought out can be applied to teams training in a virtual environment, even when the members are physically in the same room. For example, "At the level of the individual, when a team is co-located, interaction is transparent in that one is more easily able to assess a teammate's actions (e.g. monitor visual cues for stress), but distribution produces potentially unique ways that individual members may be taxed. At the level of the team, interaction behaviours normally clear may become similarly opaque." A team training in a virtual environment, with each team member reacting to the virtual environment as seen in the individual's computer, may experience the same opacity of interaction.

Fiore, et al. further argue that, "in addition to having the complex components associated with distributed team tasks influence interaction," "team members must deal with an increased level of abstraction forced upon them by their distributed nature…" (Fiore, et al., 2003). I would argue that in addition to having the complex components associated with virtual team tasks influence interaction, team members must deal with an increased level of abstraction forced upon them by the virtual environment. Further, the statements "increased ambiguity and artificiality caused by the technology-mediated interaction" and "because information flow and format is technology-mediated, the rich visual, auditory and social array of cues normally accompanying traditional team interaction are attenuated" apply to both the distributed environment and the virtual training environment.

In a discussion of Information Management, Fiore, et al. suggest that information management can occur "at differing stages of team interaction, resulting in three forms of information management….

(1) *Pre-process information management*—any form of information parsing administered prior to actual interaction.

(2) *In-process information management*—parsing information flow during task execution.

(3) *Post-process information management*—information disseminated after interaction." (Fiore, et al., 2003)

These three stages mirror any military training or operational evolution: planning and briefing, execution, and de-briefing/after action review. The primary difference between this information management in a distributed environment and a co-located virtual environment training evolution is that the team conducts normal, "face-to-face" planning and briefing as well as de-briefing/after action review. Only during the execution phase is the information management similar in nature to a distributed environment.

Fiore, et al., also "discuss the more dynamic group factors resulting from team opacity and describe them in the context of the attitudes, behaviours and cognitions associated with team interaction in a distributed coordination space" (Fiore, et al., 2003). Similar to the Team Competencies discussed earlier, they list behaviors as team coordination, team adaptability, and team cooperation; attitudes as team trust, team cohesion, collective efficacy, and collective orientation; and cognition as working memory, memory activation, and long-term memory. Most important to the discussion, I believe, is their assertion that, “Researchers propose that effective teams develop a shared understanding or shared mental model utilized to coordinate behaviours by anticipating and predicting each other’s needs and adapting to task demands (Cannon-Bowers *et al.* 1993). Furthermore, both implicit and explicit communication are important to team coordination and, for such coordination to develop, the team must have a shared mental model….coordination is often achieved via feedback mechanisms, particularly in non-routine situations. To the degree receiving and/or interpreting feedback is hindered, coordination may suffer” (Fiore, et al., 2003). This holds very true in the virtual environment as well, as team members do not have their normal capability of receiving implicit communication (hand and arm signals, facial expressions, subtle movements, etc.).

The implication of this decline in implicit cues is that team training in a virtual environment could result in teams altering their coordination attempts to include more explicit communication, thereby changing their normal operational procedures and causing negative training. This must be guarded against and some mechanism found to allow information management to proceed in as normal a manner as possible. This will require further research into the cognitive processes involved in team training in a virtual environment.

In my early experimentation, I did observe one Marine Fire Team Leader overcome this problem. In a field environment, Fire Team Leaders are very much “hands on.” If a Marine is not where the Fire Team Leader wants him, the Fire Team Leader may just grab the Marine by the backpack and physically move him. During the experiment, the Fire Team Leader was having difficulty explaining verbally to a Marine in his Fire Team exactly where in the Virtual Environment he was supposed to be positioned. The Fire Team Leader got up from his computer, walked over to the other Marine, put his hand on the Marine's shoulder, and pointed to the spot on his computer monitor, saying, "There! I want you right there!"

In another military setting, what has proven to be the most effective method to train infantrymen in a MOUT environment is the use of "simunitions" (simulated munitions) in an actual MOUT facility. These simunitions are, in effect, an adaptation of the popular paint ball. Special magazines are used and the barrels of the Marines' rifles are exchanged for special barrels that work with the simunitions. Simunitions are in high demand, and there is stiff competition among units for the use of MOUT facilities. The USMC does not have the necessary time, facilities, or equipment to fully meet the MOUT training requirement through traditional training methods. These shortfalls have been identified and both the Army and the USMC are working to provide more and improved MOUT facilities for operational units. However, construction of MOUT facilities is costly and time-consuming. Potential for supplementing MOUT training through games is suggested by the use computer games at the military academies to perform other small unit actions. As explained by Starling,

> Computer games with titles such as "Steel Beasts" and "Star-Craft," intended for home entertainment, are being used by the military academies to train the nation's future generals and admirals. The games' use by the prestigious military academies illustrates the increasing realism in computer games and the interest of military instructors in finding inexpensive and easily acquired teaching aids… (Starling, 2001)

Success at the academies infers that computer games may enable Marines to train on the cognitive skills required for MOUT. Marines may learn decision-making, communication skills, and unit Standing Operating Procedures before they go to the field. Because of the flexibility offered, units may be able to take advantage of this training when traditional training resources are unavailable. "[A]pplication of the gaming approach is the situation in which we want to teach people … how to act in a new situation. … they have to learn skills. … After the learning or the practice, students will have to apply their new knowledge or skills in the real situation.” (Peters, 1998)

The USMC has previously identified PC-based games, such as *Marine Doom*, as having training value. To date, in addition to *Marine Doom,* the *Delta Force 2*, *Rogue Spear*, *Rogue Spear: Urban Operations*, and *Operation Flashpoint* games have been evaluated for their abilities to meet USMC infantry individual training standards. “Many existing hobby or commercial war games may have the potential to be applied within the defense community. However, in addition to resistance to using civilian products for military professional education or analysis, it also is often unknown whether commercial products would teach appropriate or realistic lessons.” (Oswalt, 1993) Therefore, we must carefully measure the training transfer of such systems to determine their validity.

Investigation of the use of games for military tasks is mostly found in technical reports. For example, Coalescent Technologies Corporation conducted research and experimentation on behalf of the U.S. Marine Corps and prepared the Fire Team Cognitive Skills Trainer (FTCST) Report in March 2001 (See Appendix A). The general research objective was to determine the utility of COTS PC-based, “first-person shooter” wargames for small unit MOUT cognitive skills training. A team of researchers (myself included) under the direction of Captain J. E. Smith, USMC conducted a technology demonstration and data collection effort with members of the 3rd Battalion, 4th Marines (3/4) and supporting forces from Marine Corps Base Twentynine Palms, California. This unit was participating in the MCWL’s Project Metropolis at the former George Air Force Base in Victorville, California. One phase of Project Metropolis focuses on technology applications and MOUT training. Prior to the demonstration, the research team selected and set up a networked sixteen-PC (desktop) system running *Rogue Spear: Urban Operations* in the multi-player mode. Several different scenarios (mission areas and locations) were selected for use.

Prerequisite research questions to support the general research included:

What is the experience level of the research participants with respect to (1) USMC (age, grade, time in service) and (2) PC-based games (types, length, enjoyment, ill effects)?

What lessons are learned regarding planning, intra-team communications, tactical awareness, movement techniques, and weapons employment/fire discipline during each game of the research experiment?

What are the participants' opinions of the training system and the team's performance at the conclusion of the research experiment?

What are the participants' opinions of the training system's value as a training tool after completing a field MOUT training evolution?

What is the best training methodology for maximum training transfer?

Two of the more interesting results of the participants' opinions of the training system were:

> After training on the FTCST but before live MOUT training: How useful do you think this (PC-based game) training system will be for improving your abilities in MOUT?
>
> 3.74 (out of 5)

After training on the FTCST and <u>after</u> live MOUT training: How useful do you think the (PC-based game) training system was in improving your, or the participants', <u>overall ability/performance in MOUT</u>?

4.13 (out of 5)

This comparison is important in that it demonstrated the realization by the participants that the game-based training was even more valuable in the real-world training environment than they had thought it would be before experiencing the training environment.

<u>Objective Based Training</u>

Objective Based Training (OBT) defines, in a single source, all training objectives for an organization. OBT "defines what must be trained, how it will be trained, and how well it must be performed." (COMNAVSURFORINST 3502.1A) In the Instructional Systems Design process, OBT is associated with Terminal Learning Objectives and Enabling Learning Objectives. In fact, the US Navy Afloat Training Group Pacific "adopted the existing school house practice of curriculum development by creating a hierarchical structure of terminal and enabling objectives tied to individual and team measures of performance. This method was also designed to facilitate automated scenario generation, to support the development of 'smart' systems to objectively determine operator performance and provide recommendations for requisite remediation, and to provide a linkage between all levels of training." (Acton, 1998) More recently, the US Navy Afloat Training Organizations similarly "implemented a process that quantifies training requirements, established clear training goals and associated metrics, and provides diagnostic training feedback. This systematic approach adapts accepted schoolhouse practices of curriculum development by creating a hierarchical structure of objectives tied to individual and team measures of performance linked to Naval Mission Essential Tasks." (Acton, 2001)

Objective Based Training is often viewed as very passive. "Traditionally, *Objective-based training* places the learner in a passive role while putting the instructor in total charge of defining the objectives, building the practices and developing the test. Behavioral and cognitive training are based on this learning theory. The teacher knows and you are expected to follow the lesson plan. You know the drill." (Woodall, 2002)

However, starting this year, the United States Military Academy (USMA) is "employing objective-based training, which is the new way of saying that we are training to standard, not to time. If a squad gets lost on patrol, or a unit fails to coordinate an attack, or a leader spends so much time planning that he runs out of time to execute, the unit 'recocks' and repeats the task." (Lennox, 2003)

In the USMA manifestation of OBT, mentoring is inferred. The training evolutions must be mentored for two readily apparent reasons: (1) to prevent the training sessions from devolving into chaos—while MOUT in real life may be chaotic, chaos in the training environment is not conducive to after-action reviews which are critical to the learning process; and (2) to force the fire team leader and his Marines to go through the planning process, to deliberate on how they should solve the problem, and to review what they could have done better. It will also be important to use the same mentor for all groups within a particular evaluation occasion to eliminate the possibility of undue influence on the overall results.

In some of industry, OBT is replacing the older training philosophy in which "there was too much emphasis on individual job elements and not enough on the whole job." (Wright, 1990) Because of this, satisfactory performance on the job was not guaranteed by satisfactory performance in training. “Two major characteristics of the OBT are: (1) training is based on actual job performance requirements, and (2) learning is independent of time and is worker paced. What this means is that the ability of the worker dictates the length of the training requirement as opposed to some preset management schedule….OBT requires that all job performance be described and reduced to written form. If management knows what an employee is to do on the job (the performance) and how well that job is to be done (the referenced criterion), then there is a high probability that the worker will do the job properly.” (Wright, 1990) Of course, this only addresses Knowledge and Skills and ignores Attitudes.

Events Based Approach to Training

In its simplest form, Events Based Approach to Training (EBAT) “provides a systematic approach for developing learning objectives, generating scenarios, measuring performance, and providing feedback. EBAT has been successfully used in a number of settings to establish effective learning environments which have in turn, resulted in improved performance.” (Oser, et al., 1997) Furthermore, the techniques of this approach “guide the design of training opportunities by systematically identifying and introducing events within training exercises that provide known opportunities to observe behaviors of interest. With EBAT, explicit links are maintained between training objectives, exercise design, and performance assessment.” (Fowlkes, et al., 1998)

When we consider team training using virtual environments, “EBAT provides the strategies, methods, and tools, which are essential for an effective learning environment…, in a structured and measurable format for training and testing specific KSAs. In order to precisely control, measure, and then benefit from user responses to events, a cyclical layout of EBAT has been established.” (Salas, et al., 1999)

Naval Aviation Training Systems Division, through its Small Business Innovative Research program, has worked with a company called Cybernet to create a Training System called “OpenSkies.” “This system has closely integrated the EBAT with an OpenGL based virtual environment toolkit to produce a training scenario authoring system.” (Cybernet, 2005) Figure 2 is a diagram displaying this iterative approach.

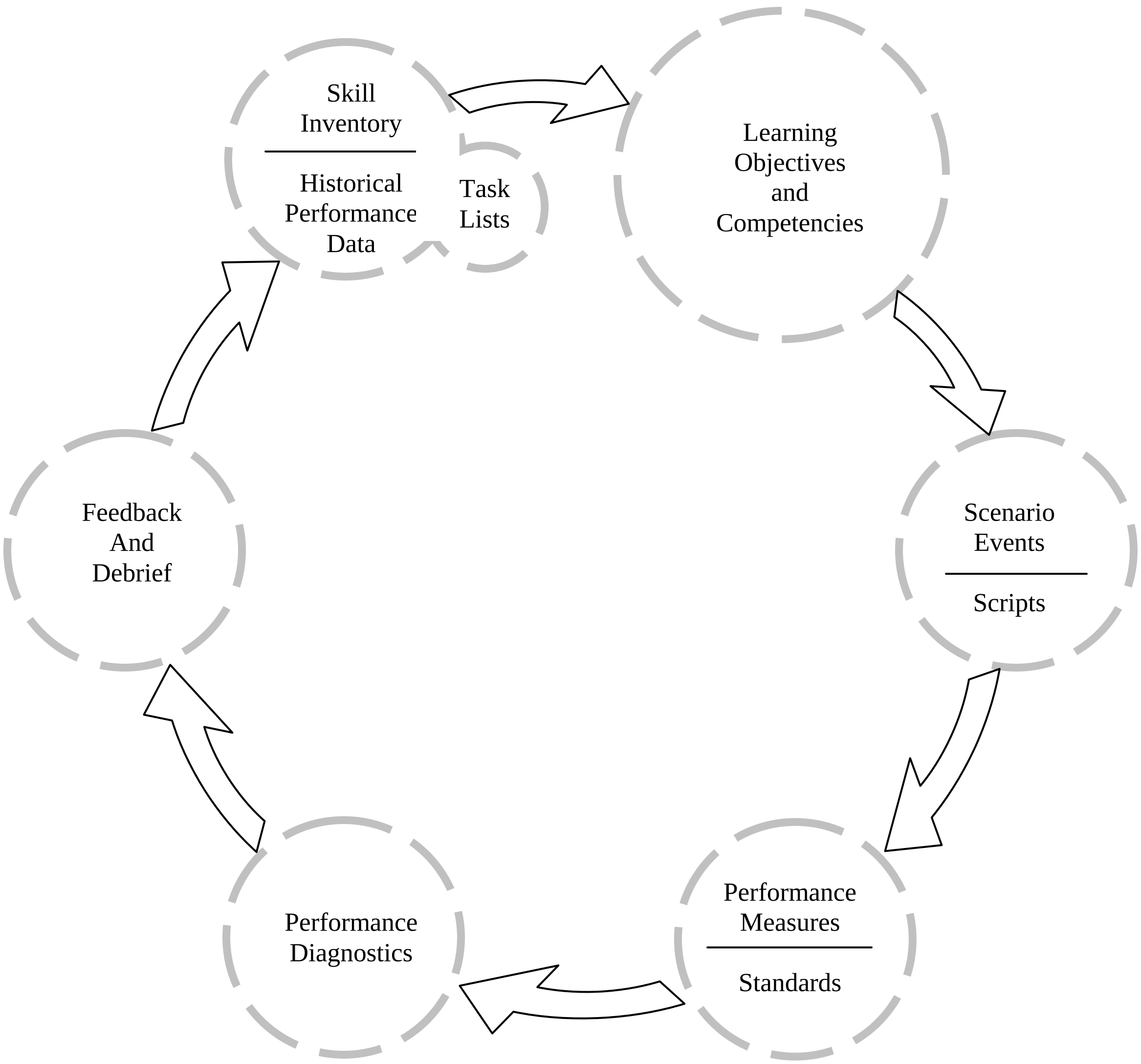

Figure 2: Systematic Approach to Training developed by Fowlkes, et al. (1994)

Beyond its use in Virtual Environments, EBAT has been used successfully for designing team performance measurement tools for use in a distributed training environment. “In distributed team training, military teams train together in the same battlespace despite the physical separation. In these types of training environments, multiple users are located at multiple sites; consequently, the efficient and effective conduct of training is a challenge. One area that is particularly challenging is the measurement of team performance.” (Dwyer, Oser, Salas, & Fowlkes, 1999)

“Event-based techniques do not depend on the chance interactions among trainees and other elements of the scenario for training; rather, they create the requirement to act.” (Fowlkes, et al., 1998)

CHAPTER THREE: METHODOLOGY

The purpose of this research is to evaluate the training transfer associated with a Tactical Decision-making game, using *Close Combat: First to Fight*™ (F2F) as a case study (see Figure 3). The null hypothesis to be tested is that traditional field training is equivalent to virtual training combined with field training. Rigorous experimentation measures the subjects' improvement in cognition when confronted with decision-making tasks. This experimentation will compare, assess, and report on training value achieved through traditional field training versus the benefits of virtual training combined with field training.

Figure 3: *Close Combat: First to Fight*™

Approach

The approach to this research is to examine a single game as a case study using the Yin (1984) Case Study Research methodology. The PC game (TDS) to be evaluated for training effectiveness is F2F. F2F is a tactical first-person shooter game developed by Destineer Studios and released to the commercial market in March 2005.

The game is focused (in the single-player mode) on a gamer who acts as a Marine fire team leader who leads a four-man fire team in close-quarters urban combat in the streets and buildings of Beirut. The typical scenario encompasses two to three blocks with limited access to buildings. Those buildings that are accessible have highly detailed interiors with cultural features such as pictures on the walls, carpets, and furniture. The doors can be opened and closed and windows can be fired through; however, most of the static items can not be manipulated.

Game scenarios will be selected that replicate, as closely as possible, the CQB Tactical Performance Evaluation in the live fire "shoot house" facility at Chesapeake, Virginia. All experimental group participants will be afforded an opportunity to learn the basics of playing the game prior to the experimentation so as to not lose training time to learning "buttonology" and so that they are thinking about their actions within the game rather than which keys to push to perform the desired actions.

An evaluation consisting of strictly controlled experimentation will be conducted in cooperation with the Marine Corps Security Force (MCSF) Training Company. Data collection will involve Marines attending the CQB Course. The class is composed of enlisted Marines who have completed Basic Training ("Boot Camp") and entry level infantry training at the Infantry Training Branch of the School of Infantry. Further, according to the Letter of Instruction (LOI) published by the MCSF Training Company, Marines must meet the following requirements to attend the course:

(a) Must score a 1st class PFT [Physical Fitness Test] within 90 days of reporting.

(b) Must be a Lance Corporal or above. A PFC [Private First Class] can only attend if they have six months time on station.

(c) All Marines during spin-ups must qualify with a minimum score of 300 on the CQB pistol qualification course.

(d) Eye sight correctable to 20/20 in both eyes. Students must have glasses, contacts and gas mask inserts/goggles for the MCU-P2 gas mask.

(e) No color blindness.

(f) Any Marine who has failed a CQB course in the past because of safety violations must have a minimum of six months before he can attend again.

(g) Not a prior heat or cold casualty within six months of reporting.

(h) On full duty status.

(i) Hearing in both ears.

(j) During the conduct of the course, there will be no commitments or concerns that will require a student to be absent from training. Any student missing any 2 training days during marksmanship or any 1 training day during tactics will be subject to automatic termination.

(k) Must be mature, professional and willing to accept constructive criticism.

(l) Must possess the ability to think/react quickly and correctly under stress.

(m) Marines must have a minimum of one-year time remaining on station upon completion of the course.

(n) Students must have all required gear IAW [In Accordance With] the course equipment list and their screening checklist.

The LOI also explains, “The program of instruction for the Close Quarters Battle course will include a wide range of intensely evaluated training evolutions that will challenge the students on a daily basis. The students will receive instruction in advanced marksmanship, basic

Close Quarters Battle tactics, Advanced Close Quarters Battle tactics, and CQB assault options." (CO, MCSFTC, 2005) Specific Individual Training Standards (ITS) are shown in Table 4.

Table 4

Index of Individual Events by Functional Area (Excerpt) (MCSF Bn T&R Manual, 2005)

MOS 8154, MCSF CQB TEAM MEMBER	
ITS	DESCRIPTION
8154-CQB-1028	Perform weapons handling procedures with the Service pistol
8154-CQB-1029	Engage stationary targets with the Service pistol
8154-CQB-1030	Engage limited exposure targets with the Service pistol
8154-CQB-1031	Engage targets in low light and darkness with the Service pistol
8154-CQB-1032	Engage multiple targets with the Service pistol
8154-CQB-1033	Engage moving targets with the Service pistol
8154-CQB-1034	Engage targets while on the move with the Service pistol
8154-CQB-1035	Perform weapons handling procedures with the M-4 Carbine
8154-CQB-1036	Maintain the M-4 Carbine
8154-CQB-1037	Zero the M-4 Carbine
8154-CQB-1038	Engage stationary targets with the M-4 Carbine
8154-CQB-1039	Engage limited exposure targets with the M-4 Carbine
8154-CQB-1040	Engage targets during low light and darkness with the M-4 Carbine
8154-CQB-1041	Engage targets with the M-4 Carbine with the field protective mask
8154-CQB-1042	Engage multiple targets
8154-CQB-1043	Engage moving targets with the M-4 Carbine
8154-CQB-1044	Engage targets while on the move with the M-4 Carbine
8154-CQB-1045	Move to the objective
8154-CQB-1046	Enter the objective
8154-CQB-1047	Clear an enclosure
8154-CQB-1048	Clear a stairwell
8154-CQB-1049	Clear a hallway
8154-CQB-1050	Clear an elevator shaft
8154-CQB-1051	Clear a vehicle
8154-CQB-1052	Negotiate an improvised explosive device
8154-CQB-1053	Control an occupant
8154-CQB-1054	Evacuate an objective
8154-CQB-1055	Employ a flash bang diversionary device
8154-CQB-1056	Perform marshalling area procedures
8154-CQB-1057	Conduct operations with a security element
8154-CQB-1058	Conduct an assault rehearsal
8154-CQB-1059	Conduct a turnover
8154-CQB-1060	Coordinate designated marksman support
8154-CQB-1061	Qualify on the CQB pistol qualification course
8154-CQB-1062	Qualify on the CQB M-4 Carbine qualification course

The full CQB Course consists of twenty training days: nine days for marksmanship, six days for tactics, four days for operations and tactical evaluation, and one day for graduation (see Figure 4). The control group and the experimental group will complete the marksmanship and tactics phases together. The experiment will be conducted during the operations and tactical evaluation (Ops/Eval) phase.

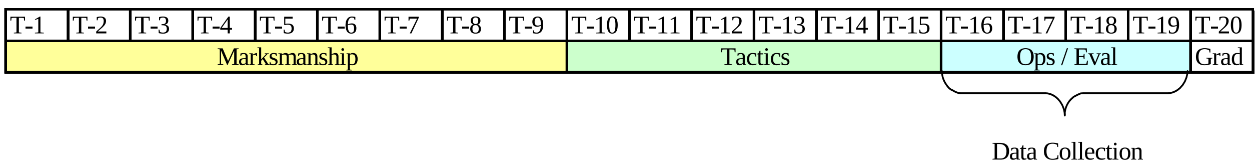

Figure 4: CQB Course Timeline

During the Ops/Eval phase, on the night before the written final examination and the live-fire Tactical Evaluation, the students are provided with approximately three hours of mentored study time and three hours of supervised "walk-throughs" of the shoot house. The experimental group will be given one additional station, the TDS, during this final study and practice period. The time spent on the TDS will be taken from the time that would have been devoted to study and practice. As a result, the training will be as in Table 5 (not necessarily in the listed sequence):

Table 5
Study, Practice, and TDS Times

Control Group			Experimental Group	
			TDS	2 hrs.
Examination Study	3 hrs.		Examination Study	2 hrs.
Shoot House	3 hrs.		Shoot House	2 hrs.

Marines attending the course will be randomly assigned to eight-man teams to rotate between Examination Study, the Shoot House, and, for the experimental group, the TDS. During this evaluation phase, complete and accurate data collection will be accomplished.

Additionally, the total amount of training time, whether in a group participating in F2F training or not, must be equal to eliminate the possibility that simply providing additional training time might account for any differences in performance rather than the use of the computer game. It should be noted that a significant amount of "training time" is currently wasted by sitting around waiting for a turn in the shoot house.

Design of the Experiment

The initial intent was to establish a Solomon Four-Group Design at the experimental site. This particular design includes two control groups and two experimental groups, with one control group and one experimental group being pre-tested and all four groups being post-tested. The desire was to ensure that a pre-test would not impact the validity of the combined virtual training and field training. However, because the live training venue for this experiment involves live weapons firing in the shoot house, it is imperative for safety reasons that all groups be pre-tested. Therefore, there will be one control group consisting of sixteen Marines with one observation per Marine and one experimental group consisting of sixteen Marines with one observation per Marine. I will use the Mann-Whitney Test, a non-parametric test used to compare two independent groups of sampled data. This test uses the ranks of the data rather than their raw values to calculate the statistic. The hypotheses for the two independent groups are:

$H._0$: The two samples come from identical populations; that traditional field training is equivalent to virtual training combined with field training

H_a: The two samples come from different populations; that there is a difference between traditional field training alone and virtual training combined with field training

Participants will be asked to complete an informed consent document (see Appendix B) and will be pre-screened based on age, time of service, previous training, normal billet, and experience with computer games (see Appendix C). The total scores of each individual will then be compared for an analysis of the training effectiveness. Based on Kirkpatrick's Hierarchy:

- Reactions (attitudes about training)
- Learning (permanent cognitive change)
- Behavior ((transfer) on-the-job)
- Results (initial problem solution, e.g., safety, mission success, cost savings),

this analysis will provide a reliable prediction of the training transfer resulting from the PC-based wargames used in the training.

<u>Assessment</u>

"Interpreting the mass quantities of performance data … that are captured in some team settings, in some meaningful way is a daunting task at best. What knowledge requirements and behavioural skills lie behind those measures? It is vitally important that solid links are established between knowledge requirements, training objectives and performance indicators." (Paris, Salas, & Cannon-Bowers, 2000)

Similar to the need for consistent mentors, the Observer/Controllers (O/Cs) who oversee the CQB/MOUT Exercise must be the same throughout each evaluation occasion to ensure consistency of the results of the exercise evaluation. The O/Cs will not be informed whether each fire team under evaluation is part of the control group or the experimental group to ensure that no bias is introduced into the evaluation. This evaluation is, by its very nature, subjective so it is imperative to have consistency.

<u>Applying EBAT to the Development of a PC Game-Based Training Application</u>

I used the EBAT cycle as provided by Salas, et al. (1999) as the basis for developing my training transfer evaluation.

1. Skill Inventory/Performance Data

The task analysis, cognitive task analysis, and team task analysis are based upon the Marine Corps Combat Readiness Evaluation System for those tasks applicable to MOUT.

2. Learning Objectives/Competencies

The Knowledge, Skills, and Attitudes will be based upon the Marine Corps ITSs for Infantry for those tasks applicable to CQB.

3. Scenario Scripts/Trigger Events

Based on steps one and two, I developed scenarios to be executed in the game. The specifics regarding the scenario and trigger events are maintained in a master scenario event list.

4. Performance Measures/Standards

Performance measures and standards are based upon the MCSF Training Company Program of Instruction and are delineated in the CQB Tactical Performance Evaluation.

5. Performance Diagnosis

Performance will be diagnosed based upon the participants' actions in response to the scenario and events as compared to the performance measures and standards.

6. Feedback and Debrief

Constructive and specific feedback will be provided to all team members immediately upon completion of each scenario.

7. Incorporate into Future Training and Archive Data in a Meaningful Manner

Lessons Learned during the training and experimentation will be recorded and incorporated into future experiments and training exercises.

Table 6 indicates the tasks and point values of each task to be evaluated. The written post-test is objective but can not reflect the command, control, communications, coordination, cooperation, and cognition that the game strives to train.

Table 6
CQB Tactical Performance Evaluation

TASK	**POINTS**
ENTRY POINT / BREACH POINT	
Proper team stack	1
Passed ready signal / Initiates Countdown	1
INITIAL ENTRY (Closed Door / Student will enter as #3 Man	
Conducts Proper 5 Step Entry	5
Proper Three-Man Entry	1
ROOM 1 (Open Door)	
Proper Hallway Assessment / Coordination	2
Conducts Proper 5 Step Entry	5
Proper Two-man Entry	1
Shot Delivery (Hammer Pair)	1
Shot Placement (PSP -2 per round, two rounds total / Flyer -4)	4
Conducts Door Check	1
Conducts Dead Check	2
Conducts Proper Marking Procedures	1
Maintains Tactical Advantage / IBT	3
ROOM 2 (Open Door)	
Proper Hallway Assessment / Coordination	2
Conducts Proper 5 Step Entry	5
Proper Three-Man Entry	1
Shot Delivery (Hammer Pair)	1
Shot Placement (PSP -2 per round, 2 rounds total / Flyer -4)	4
Conducts Dead Check	2
Conducts Proper Marking Procedures	1
Maintains Tactical Advantage / IBT	3
ROOM 3 (Closed Door)	
Proper Hallway Assessment / Coordination	2
Conducts Proper Door Procedure	1
Conducts Proper 5 Step Entry	5
Proper Two-Man Entry	5
Shot Delivery (Failure Drill)	1
Applies Appropriate Immediate Action	2
Shot Placement (PSP -2 per round, 4 rounds total / Flyer -8)	8
Clears Immediate Danger Area (Furniture)	2
Conducts Dead Check	2
Conducts Proper Reload	2
Conducts Proper Marking Procedures	1
Maintains Tactical Advantage / IBT	3
ROOM 4 (Closed Door / Enters Room as 2nd Support Shooter)	
Proper Hallway Assessment / Coordination	2

Bumps Shooter Off Door / Conducts Door Check	1
Clears Stairwell Up	2
Sounds Off "LAST ROOM"	1
Conducts Proper Marking Procedures	1
Maintains Tactical Advantage / IBT	3
POST ASSAULT	
Reports Objective Secure	1.5
Establishes Strongpoints	1.5
Submits a Proper Situation Report	2
Links Up with Guard Force	2
Conduct Walk Through / Change Over	1.5
Request to Evacuate Assault Force	1.5
Link Up with DM (Mark / Confirmation)	1.5
Evacuate Assault Force from Objective	1.5
SAFETY VIOLATIONS	
Live Fire N.D.	-25
Live Fire Muzzling	-25
Finger on Trigger	-10
Door Check at the Index	-10
Weapon on Fire	-5
Failure to Decock	-5
Failure to Abide by the Six Foot Rule	-5
RAW SCORE	
SAFETY VIOLATIONS	
FINAL SCORE (Passing 80/100)	

CHAPTER FOUR: FINDINGS

The Set-Up

I traveled to Chesapeake, Virginia on 3 November 2005 to meet with the Marine Corps Security Forces Training Company's CQB Course Officer in Charge, Captain Peter Young, USMC and the CQB instructors. I showed them a Marine Corps film, "Tactical Decision-making," and demonstrated the F2F TDS, using two laptop computers from a DVTE training suite, to familiarize them with the software. I also presented the experiment plan for their awareness.

On 4 November, I again met with Captain Young to discuss the details of the experiment plan and to teach him how to review the various scenarios available in First to Fight as well as how to use the editor to modify the scenarios. The two laptop computers were left with Captain Young for his and his staff's use in familiarizing themselves more completely with the TDS, as well as to review the various "levels" or terrains available.

I returned to Chesapeake on 13 November, bringing with me another six DVTE laptop computers to establish a simulation room for the experiment. Unfortunately, the airline misrouted the computers, leaving me empty-handed at the airport! They showed up about eight hours later, too late for setting up as planned. Additionally, four desktop computers were to have been shipped from the developer of the software to augment the DVTE computers. The plan was to have eight DVTE laptop computers for the experimental group, two computers for the instructors acting as the opposing forces (OpFor), one computer as an observer station, and one spare. The desktops were never shipped!

Monday, 14 November was to be a familiarization day for the experimental group to become acquainted with the software. The group was to be divided into two sessions of eight participants per session for a total of 16 participants in the overall experimental group. Because of unforeseen schedule changes at the school, the entire group showed up at one session. Further, one of the laptop computers refused to cooperate, so we were forced to conduct the familiarization for sixteen Marines on seven computers. Fortunately, more than half of them were already familiar with F2F, so most of the roughly 45 minutes of computer time was allocated to the Marines who had not played the commercial game previously. The familiarization consisted of playing the standard game without concern for actual tactics simply to provide the Marines with an opportunity to learn the basic commands and controls of the game. Additionally, all sixteen Marines were given an opportunity during the 45 minutes familiarization to use the new “Marine Combat Pad,” (see Figure 5) an input device designed to simplify entering commands with one hand while using the other for the mouse inputs.

Figure 5: CQB Marine in Action; Marine Combat Pad

On Tuesday, 15 November, I was able to rent one desktop computer and on Wednesday, 16 November, I was able to rent two more desktop computers and set them up in the simulation room prior to the evening experiment. The layout was modified slightly, with the eight experimental subjects and the two instructor OpFor using the ten computers as shown in Figure 6 but with no observer station and no spare available.

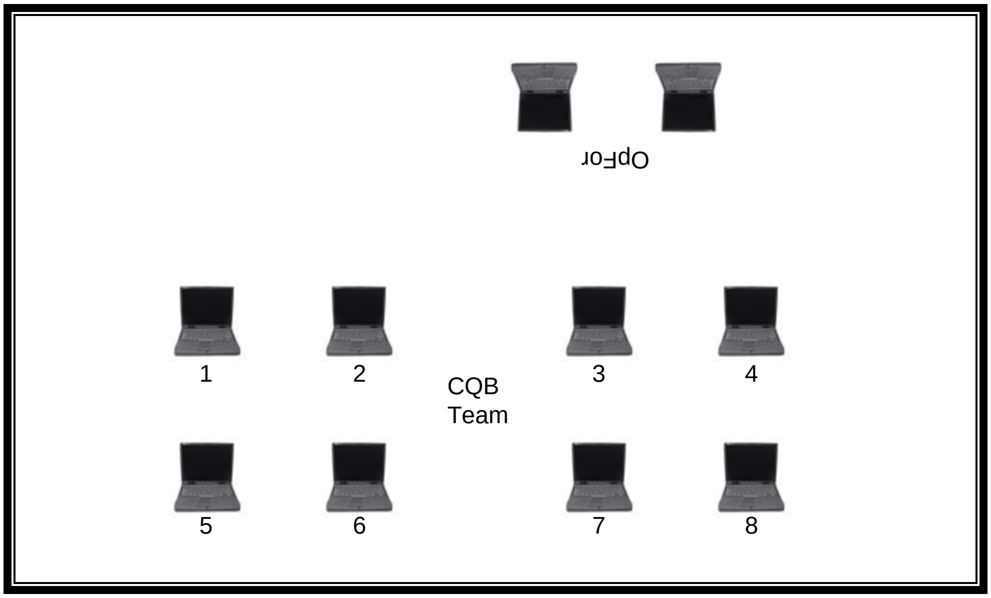

Figure 6: Computer Layout

The experiment

In the late afternoon of Wednesday, 16 November, the two instructors who were to play the roles of the OpFor came in to rehearse their actions that they would take during the training. In the early evening, the first half of the experimental group showed up while the other half of the experimental group and the control group alternated between supervised studying for the written final exam and conducting mentored walk-throughs of the final Tactical Evaluation. They had just completed roughly 36 hours of field exercises, so were somewhat tired and things were a bit slow to get going.

The subjects were provided with the Informed Consent form (Appendix B) and I explained it to them; none declined to participate. They then completed the Demographics

Questionnaire (Appendix C), the Simulator Sickness Questionnaire (Appendix D), and the Baseline (Pre) Exposure Symptom Checklist (Appendix E).

Experimental Group Treatment: The experimental groups then proceeded through a series of missions following the pattern of:

Mission brief and planning – the instructors briefed the mission and prepared the scenario and the Marines would be given a short time for planning (see Figure 7).

Figure 7: CQB Instructor Briefing the Mission While another Instructor Prepares the Scenario

Execution – the Marines executed their plan in the simulation as an eight-man team, using the Tactics, Techniques, and Procedures (TTP) that they had been taught in the school (see Figure 8). The OPFOR consisted of two terrorist avatars deployed inside buildings and controlled by two instructors.

Figure 8: CQB Marines during Execution

After Action Review – the instructors (see Figure 9) and the Marines discussed jointly how the plan fared; how they conducted the TTPs, including command and control (team leader), communications, coordination, and cooperation as team members, and cognition as individuals; and how they could improve in the next mission.

Figure 9: CQB Officer in Charge Observing Marines during Execution to Prepare for the Debrief

Post exercise Survey: After approximately an hour-and-a-half of instructor-created missions in First to Fight, the subjects completed a Post 00 Minutes Exposure Symptom Checklist (Appendix F) and a Post-Experiment Questionnaire (Appendix G).

At this point the two halves of the experimental group swapped places and the second group ran through the experiment precisely as the first group had done.

The Demographics

A complete summary of the survey of participant demographics is found at Appendix H. Highlights from the demographic survey are as follows: The "average" Marine experimental subject was a 19 ½ year old Lance Corporal with fourteen months in the Marine Corps who plays 4 ½ hours of video games per week. All subjects stated that they had played a First Person Shooter and nearly all had played Role Playing Games and Real Time Strategy games. About a third admitted to playing one or more of these types of videogames regularly. As mentioned earlier, just over half had played Close Combat: First to Fight previously.

None of the Marines had consumed an alcoholic beverage in the previous 24 hours (they were conducting field training) and none had taken any medication stronger than aspirin. However, because of the field exercises, they averaged only 2 ½ hours of sleep in the previous 36 hours. Interestingly, a third stated that they had had enough sleep.

The Tactical Evaluation

On Thursday, 17 November, each student was evaluated on his performance in conducting CQB in the live fire shoot house. Each student was placed into a four-man CQB team (one student with three instructors), the same three instructors running each of the 32 Marines through the Tactical Evaluation. This ensured that any variability in performance was directly attributable to the student and not to the other team members as could be the case in a team evaluation. Additionally, an instructor O/C followed behind the team and another instructor observed remotely via video cameras (see Figure 10). Students who completed their evaluation were kept segregated form the students who were waiting their turns. Each student was confronted with the same mission, rooms to clear, and targets to engage.

Figure 10: CQB Instructors Observing Marines Remotely during the Tactical Evaluation

The Tactical Evaluation score sheet had been modified by the schoolhouse prior to this evolution. The revised score sheet is reproduced in Table 7 below, with those areas that had corresponding training objectives in the F2F experiment highlighted:

Table 7
Revised CQB Tactical Performance Evaluation

TEST #1,2,3	**Name:**	
	Class:	
Score:	**Date:**	
TASK	**POINTS**	**SCORE**
ROOM 1 (Open Door)		
Proper Hallway Assessment / Coordination	-2	
Conducts Proper 5 Step Entry	-5	
Immediate Action	-2	
Shot Delivery	-2	
Shot Placement (Flyer -4)	-4	
Conducts Door Check	-1	
Conducts Dead Check	-2	
Conducts Proper Marking	-1	
Maintains Tactical Advantage / IBT	-3	
Reload	-2	
Stairwell Up / Down	-2	
POST ASSAULT		
Reports Objective Secure	-3	
Establishes Strongpoints	-1	
Submits A Proper Situation Report	-2	
Links Up With Guard Force	-1	
Conduct Walk Through / Change Over	-1	
Request to Evacuate Assault Force	-1	
Link Up With DM (Mark / Confirmation)	-1	
Security Shooter	-3	
Evacuate Assault Force From Objective	-1	
SAFETY VIOLATIONS		
Live Fire N.D.	F	
Live Fire Muzzling	F	
Finger on Trigger	-15	
Door Check at the Index	-10	
Weapon on Fire	-5	
Failure to Decock	-10	
Failure to Abide By The Six Foot Rule	-10	
RAW SCORE		100
SAFETY / TACTICAL VIOLATIONS		
FINAL SCORE (Passing 80 / 100)		

Marines who failed the Tactical Evaluation were given a second opportunity to pass; however, their original scores were used for this experiment. Eight Marines (two in the Experimental Group and six in the Control Group) failed the Tactical Evaluation as a result of safety violations the first time through and received scores of 0. Only one of the eight Marines passed on his second try; the others were dropped from the class (yes, the day before graduation from a four-week course!).

<u>The Numbers</u>

Results will be approached from four different perspectives: Total scores for all 32 Marines, total scores for the 24 Marines without safety failures, tactical scores (without safety violation deductions) for the 24 Marines, and TDS-related scores (those scoring categories that had related training objectives during the TDS exercise) for the 24 Marines. Each case will be analyzed with both the Mann-Whitney and the Chi Square non-parametric tests. Recall the basic hypotheses:

$H_{\cdot 0}$: The two samples come from identical populations; that traditional field training is equivalent to virtual training combined with field training

H_a: The two samples come from different populations; that there is a difference between traditional field training alone and virtual training combined with field training

Total Scores for All Thirty-Two Marines

The first examination includes all thirty-two Marines in the test population, including the eight who failed out of the course. The raw scores can vary between 0 and 100. The individual activity scores can be seen in Appendix I. Table 8 shows the results of the Mann-Whitney Test for $n_a = 16$; $n_b = 16$:

Table 8
Mann-Whitney Test for All 32 Marines

	Ranks			Scores	
	Experimental Group	**Control Group**		**Experimental Group**	**Control Group**
1	10.5	9		77	73
2	18	4.5		84	0
3	24.5	13		88	81
4	14.5	22		82	87
5	22	31		87	92
6	10.5	29.5		77	91
7	16	18		83	84
8	24.5	27		88	89
9	20	14.5		86	82
10	4.5	29.5		0	91
11	32	27		95	89
12	22	4.5		87	0
13	18	4.5		84	0
14	12	4.5		78	0
15	27	4.5		89	0
16	4.5	4.5		0	0
Sum:	280.5	247.5	Avg:	74.06	53.69

The sum of the ranks for the Experimental Group, T_A = 280.5. $T_{A[max]}$ = 392. The difference between T_A and $T_{A[max]}$ (U_A) is 111.5. Based on the table of critical values of U for n_a = 16; n_b = 16, the lower limit for a .05 level of significance for a directional test is 83. In order to reject the null hypothesis, the value of T_A would have to be less than 83. (Since, in this case, we want the ranks of the Experimental Group to be larger, the resulting value of U would have to be smaller.) Therefore, the null hypothesis cannot be rejected for this examination even though the average scores appear to be quite different (74.06 vs. 53.69).

To confirm this result, the Chi Square Test follows in Table 9 (excerpted):

Table 9
Chi Square Test for All 32 Marines

Total Score:	95	94	93	92	91	90	89	88	87	86	85	84	83	82	81	80	79	78	77	76	75	74	73	0
Experimental Group	1	0	0	0	0	0	1	2	2	1	0	2	1	1	0	0	0	1	2	0	0	0	0	2
Exper Group Expected	.5	0	0	.5	1	0	1.5	1	1.5	.5	0	1.5	.5	1	.5	0	0	.5	1	0	0	0	.5	4
Exper Group Chi Square	.5	0	0	.5	1	0	.2	1	.2	.5	0	.2	.5	0	.5	0	0	.5	1	0	0	0	.5	1
Control Group	0	0	0	1	2	0	2	0	1	0	0	1	0	1	1	0	0	0	0	0	0	0	1	6
Control Group Expected	.5	0	0	.5	1	0	1.5	1	1.5	.5	0	1.5	.5	1	.5	0	0	.5	1	0	0	0	.5	4
Control Group Chi Square	.5	0	0	.5	1	0	.2	1	.2	.5	0	.2	.5	0	.5	0	0	.5	1	0	0	0	.5	1
Total	1	0	0	1	2	0	3	2	3	1	0	3	1	2	1	0	0	1	2	0	0	0	1	8

Total Chi Square = 16; Degrees of Freedom = 100; Critical Value (.05) = 124.342. Again, we cannot reject the null hypothesis.

One additional test was run for this population, Fisher's Exact Probability Test, to determine if the difference between the number of Marines in the experimental group who passed the Tactical Evaluation was significantly different from the number of Marines in the control group who passed it. The table of frequency values follows in Table 10:

Table 10
Fisher's Exact Probability Test for All 32 Marines

Test Status	TDS	Control	Combined
Pass	14	10	24
Fail	2	6	8
Totals	16	16	32

The result of this test is 0.11, so the number of Marines in the experimental group that passed the Tactical Evaluation versus the number of Marines in the control group that passed is not statistically significant.

Total Scores for the Twenty-Four Marines without Safety Failures

The next examination includes only the twenty-four Marines of the test population who did not fail the course because of safety infractions. The raw scores can still vary between 0 and 100. The individual activity scores can be seen in Appendix I. Table 11 shows the results of the Mann-Whitney test for $n_a = 14$; $n_b = 10$:

Table 11
Mann-Whitney Test for 24 Marines without Safety Failures

	Ranks			**Scores**	
	Experimental Group	**Control Group**		**Experimental Group**	**Control Group**
1	2.5	1		77	73
2	10	5		84	81
3	16.5	14		88	87
4	6.5	23		82	92
5	14	21.5		87	91
6	2.5	10		77	84
7	8	19		83	89
8	16.5	6.5		88	82
9	12	21.5		86	91
10	24	19		95	89
11	14			87	
12	10			84	
13	4			78	
14	19			89	
Sum:	159.5	140.5	Avg:	84.64	85.9

The sum of the ranks for the Experimental Group, $T_A = 159.5$. $T_{A[max]} = 245$. The difference between T_A and $T_{A[max]}$ (U_A) is 85.5. Based on the table of critical values of U for $n_a = 14$; $n_b = 10$, the lower limit for a .05 level of significance for a directional test is 41. In order to reject the null hypothesis, the value of T_A would have to be less than 41. Therefore, the null hypothesis cannot be rejected for this examination.

To confirm this result, the Chi Square Test follows in Table 12 (excerpted):

Table 12
Chi Square Test for 24 Marines without Safety Failures

Total Score:	95	94	93	92	91	90	89	88	87	86	85	84	83	82	81	80	79	78	77	76	75	74	73
Experimental Group	1	0	0	0	0	0	1	2	2	1	0	2	1	1	0	0	0	1	2	0	0	0	0
Experimental Group Expected	0.6	0	0	0.6	1.2	0	1.8	1.2	1.8	0.6	0	1.8	0.6	1.2	0.6	0	0	0.6	1.2	0	0	0	0.6
Experimental Group Chi Square	0.3	0	0	0.6	1.2	0	0.3	0.6	0	0.3	0	0	0.3	0	0.6	0	0	0.3	0.6	0	0	0	0.6
Control Group	0	0	0	1	2	0	2	0	1	0	0	1	0	1	1	0	0	0	0	0	0	0	1
Control Group Expected	0.4	0	0	0.4	0.8	0	1.3	0.8	1.3	0.4	0	1.3	0.4	0.8	0.4	0	0	0.4	0.8	0	0	0	0.4
Control Group Chi Square	0.4	0	0	0.8	1.6	0	0.5	0.8	0.1	0.4	0	0.1	0.4	0	0.8	0	0	0.4	0.8	0	0	0	0.8
Total	1	0	0	1	2	0	3	2	3	1	0	3	1	2	1	0	0	1	2	0	0	0	1

Total Chi Square = 13.71; Degrees of Freedom = 100; Critical Value (.05) = 124.342. Again, we cannot reject the null hypothesis.

Tactical Scores for the Twenty-Four Marines without Safety Failures

This examination again includes only the twenty-four Marines of the test population who did not fail the course because of safety infractions. However, rather than looking at the total score, which includes safety violations, we look only at the tactical score. Most live fire safety rules (such as negligent discharge, finger on the trigger when not intending to shoot, weapon on fire rather than safe when not intending to shoot, and failure to de-cock the service pistol) cannot be replicated in the TDS so it is not unreasonable to exclude them from the analysis. The raw scores can only vary between 60 and 100. The individual activity scores can be seen in Appendix I. Table 13 shows the results of the Mann-Whitney test for $n_a = 14$; $n_b = 10$:

Table 13
Mann-Whitney Test for Tactical Scores of 24 Marines without Safety Failures

	Ranks			**Scores**	
	Experimental Group	**Control Group**		**Experimental Group**	**Control Group**
1	7.5	3		87	83
2	23	17.5		94	91
3	11	7.5		88	87
4	1.5	20.5		82	92
5	7.5	17.5		87	91
6	20.5	4.5		92	84
7	22	14		93	89
8	11	1.5		88	82
9	17.5	17.5		91	91
10	24	14		95	89
11	7.5			87	
12	4.5			84	
13	11			88	
14	14			89	
Sum:	182.5	117.5	Avg:	88.93	87.90

The sum of the ranks for the Experimental Group, T_A = 182.5. $T_{A[max]}$ = 245. The difference between T_A and $T_{A[max]}$ (U_A) is 62.5. Based on the table of critical values of U for n_a = 14; n_b = 10, the lower limit for a .05 level of significance for a directional test is 41. In order to reject the null hypothesis, the value of T_A would have to be less than 41. Therefore, while closer than the previous examination, the null hypothesis still cannot be rejected for this examination.

To confirm this result, the Chi Square Test (excerpted) is shown in Table 14:

Table 14
Chi Square Test for Tactical Scores of 24 Marines without Safety Failures

Total Score:	95	94	93	92	91	90	89	88	87	86	85	84	83	82
Experimental Group	1	1	1	1	1	0	1	3	3	0	0	1	0	1
Experimental Group Expected	0.6	0.6	0.6	1.2	2.3	0	1.8	1.8	2.3	0	0	1.2	0.6	1.2
Experimental Group Chi Square	0.3	0.3	0.3	0	0.8	0	0.3	0.9	0.2	0	0	0	0.6	0
Control Group	0	0	0	1	3	0	2	0	1	0	0	1	1	1
Control Group Expected	0.4	0.4	0.4	0.8	1.7	0	1.3	1.3	1.7	0	0	0.8	0.4	0.8
Control Group Chi Square	0.4	0.4	0.4	0	1.1	0	0.5	1.3	0.3	0	0	0	0.8	0
Total	1	1	1	2	4	0	3	3	4	0	0	2	1	2

Total Chi Square = 8.91; Degrees of Freedom = 40; Critical Value (.05) = 51.805. Again, we cannot reject the null hypothesis.

TDS-Related Scores for the Twenty-Four Marines without Safety Failures

This final examination again includes only the twenty-four Marines of the test population who did not fail the course because of safety infractions. This time, we take it one step further. Rather than looking at the total tactical score, we look only at the scoring aspects determined before-hand (as highlighted on the Tactical Evaluation score sheet) to be truly subject to training by the TDS. Many of the tactical tasks (such as immediate action for a weapon malfunction, conducting a “dead check,” properly marking a room, and evacuating the assault force from the objective [as soon as all of the Opposing Force is eliminated, the simulation ends]) cannot be replicated in the TDS so it is not unreasonable to exclude them from the analysis. Hence, the raw scores can only vary between 82 and 100. The individual activity scores can be seen in Appendix I. Table 15 shows the results of the Mann-Whitney test for $n_a = 14$; $n_b = 10$:

Table 15
Mann-Whitney Test for TDS-Related Scores of 24 Marines without Safety Failures

	Ranks			Scores	
	Experimental Group	**Control Group**		**Experimental Group**	**Control Group**
1	6	2		92	90
2	15.5	15.5		94	94
3	20.5	15.5		95	94
4	3	20.5		91	95
5	6	6		92	92
6	20.5	6		95	92
7	23	10.5		96	93
8	20.5	15.5		95	94
9	15.5	10.5		94	93
10	24	10.5		97	93
11	10.5			93	
12	1			89	
13	6			92	
14	15.5			94	
Sum:	187.5	112.5	Avg:	93.5	93.0

The sum of the ranks for the Experimental Group, T_A = 187.5. $T_{A[max]}$ = 245. The difference between T_A and $T_{A[max]}$ (U_A) is 57.5. Based on the table of critical values of U for n_a = 14; n_b = 10, the lower limit for a .05 level of significance for a directional test is 41. In order to reject the null hypothesis, the value of T_A would have to be less than 41. Therefore, while still closer than the previous examination, the null hypothesis cannot be rejected for this examination.

To confirm this result, the Chi Square Test (excerpted) is shown in Table 16:

Table 16
Chi Square Test for TDS-Related Scores of 24 Marines without Safety Failures

Total Score:	97	96	95	94	93	92	91	90	89
Experimental Group	1	1	3	3	1	3	1	0	1
Experimental Group Expected	0.6	0.6	2.3	3.5	2.3	2.9	0.6	0.6	0.6
Experimental Group Chi Square	0.3	0.3	0.2	0.1	0.8	0	0.3	0.6	0.3
Control Group	0	0	1	3	3	2	0	1	0
Control Group Expected	0.4	0.4	1.7	2.5	1.7	2.1	0.4	0.4	0.4
Control Group Chi Square	0.4	0.4	0.3	0.1	1.1	0	0.4	0.8	0.4
Total	1	1	4	6	4	5	1	1	1

Total Chi Square = 6.72; Degrees of Freedom = 18; Critical Value (.05) = 28.869. Yet again, we cannot reject the null hypothesis.

The Feedback

At the conclusion of each (experimental) training session, the Marines of the experimental group were asked to complete the Post-Experiment Questionnaire. The specific question asked was, "How useful do you think the Tactical Decision-making Simulation was in providing an opportunity for students to improve on these skills to execute the mission?" Table 17 and Figure 11 show the aggregated results.

Table 17
Post-Experiment Questionnaire Results

	Planning	Situational Awareness	Intra-Team Comms	Tactical Awareness	Movement Techniques	Weapons Employment	Rules of Engagement
	2	2	4	3	3	3	2
	3	5	4	4	3	3	3
	4	4	5	4	4	3	4
	4	4	5	4	4	3	4
	3	3	3	3	4	3	2
	3	4	5	5	5	3	2
	5	5	5	4	5	3	2
	4	4	3	3	2	2	3
	4	4	5	5	5	5	4
	3	3	3	2	2	2	2
	4	5	4	5	4	4	4
	3	3	2	4	4	4	4
	4	4	4	4	4	3	4
	4	3	2	4	4	3	3
	4	4	4	4	2	1	4
	2	3	4	4	4	4	3
Avg:	3.5	3.75	3.88	3.88	3.69	3.06	3.13

Scale: 1 = Not at all useful; 2 = Not very useful; 3 = Neutral; 4 = Useful; 5 = Very Useful

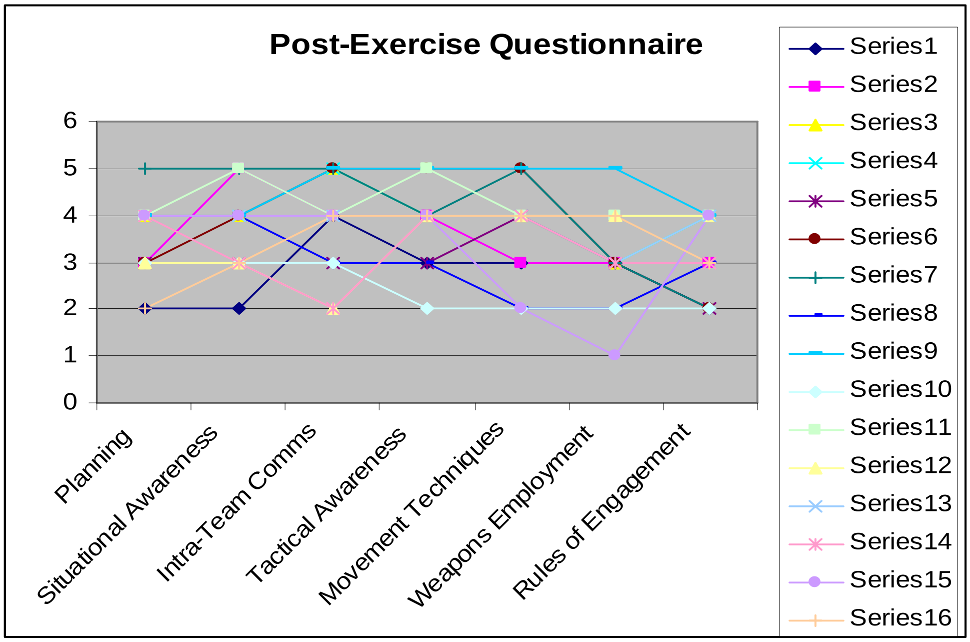

Figure 11: Post Exercise Questionnaire Graph

In the following section, we will look at the Marines' responses to each question.

1. Planning. The average of the responses to the question, "How useful do you think the Tactical Decision-making Simulation was in providing an opportunity for students to improve on planning to execute the mission?" was 3.5. See Figure 12 for a comparison of responses to the expected responses in a normal distribution. Table 18 displays the results of the t-Test.

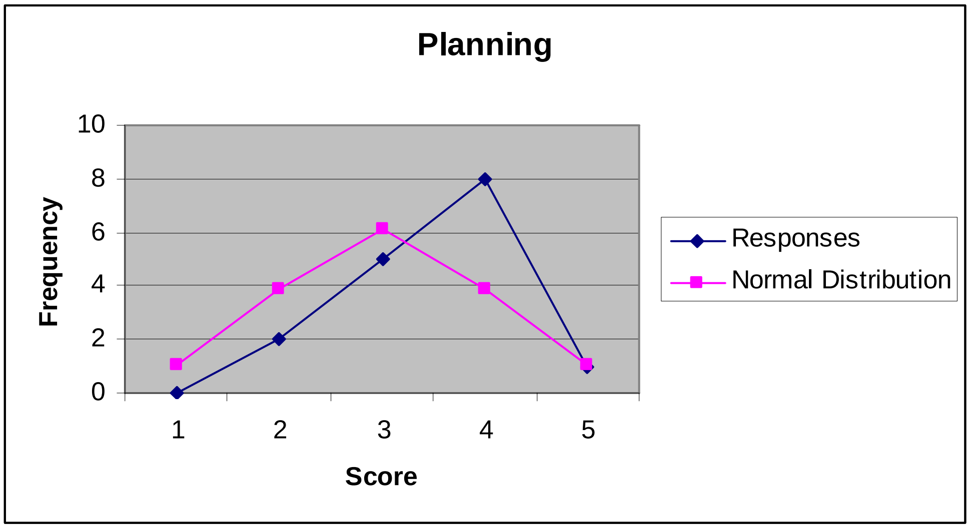

Figure 12: Responses to Planning vs. Normal Distribution

Table 18
t-Test: Paired Two Sample for Means of Planning vs. Normal Distribution

	Planning	*Normal Dist*
Mean	3.5	3
Variance	0.666666667	1.06666667
Observations	16	16
Pearson Correlation	0.079056942	
Hypothesized Mean Difference	0	
df	15	
t Stat	1.58113883	
P(T<=t) one-tail	0.067349412	
t Critical one-tail	1.753051038	

The t-value is not large enough for the responses to Planning to be statistically significant compared to a normal distribution.

2. Situational Awareness. The average of the responses to the question, “How useful do you think the Tactical Decision-making Simulation was in providing an opportunity for students to improve on situational awareness to execute the mission?” was 3.75. See Figure 13 for a comparison of responses to the expected responses in a normal distribution. Table 19 displays the results of the t-Test.

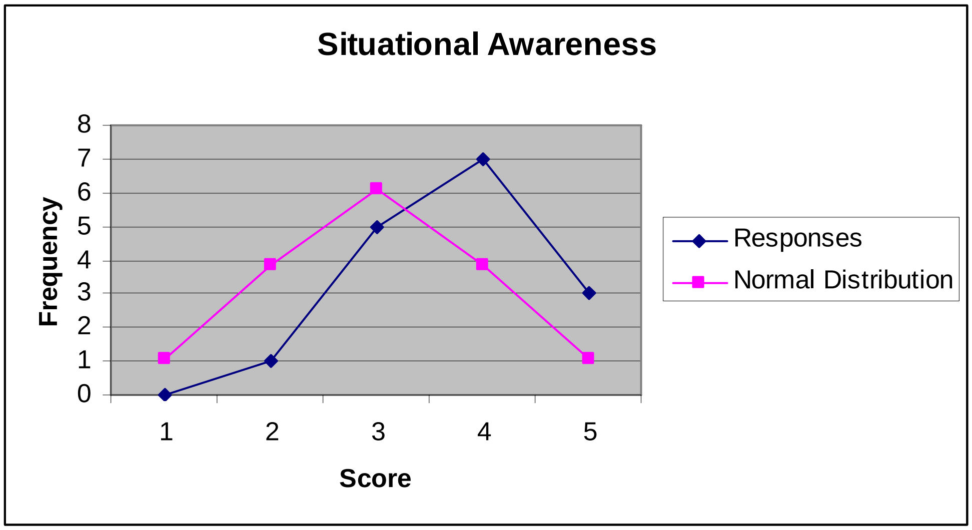

Figure 13: Responses to Situational Awareness vs. Normal Distribution

Table 19
t-Test: Paired Two Sample for Means of Situational Awareness vs. Normal Distribution

	Situational Awareness	*Normal Dist*
Mean	3.75	3
Variance	0.733333333	1.06666667
Observations	16	16
Pearson Correlation	0	
Hypothesized Mean Difference	0	
df	15	
t Stat	2.236067977	
P(T<=t) one-tail	0.020484478	
t Critical one-tail	1.753051038	

The t-value is large enough for the responses to Situational Awareness to be statistically significant compared to a normal distribution.

3. Intra-Team Communications. The average of the responses to the question, “How useful do you think the Tactical Decision-making Simulation was in providing an opportunity for students to improve on intra-team communications to execute the mission?” was 3.88. See Figure 14 for a comparison of responses to the expected responses in a normal distribution. Table 20 displays the results of the t-Test.

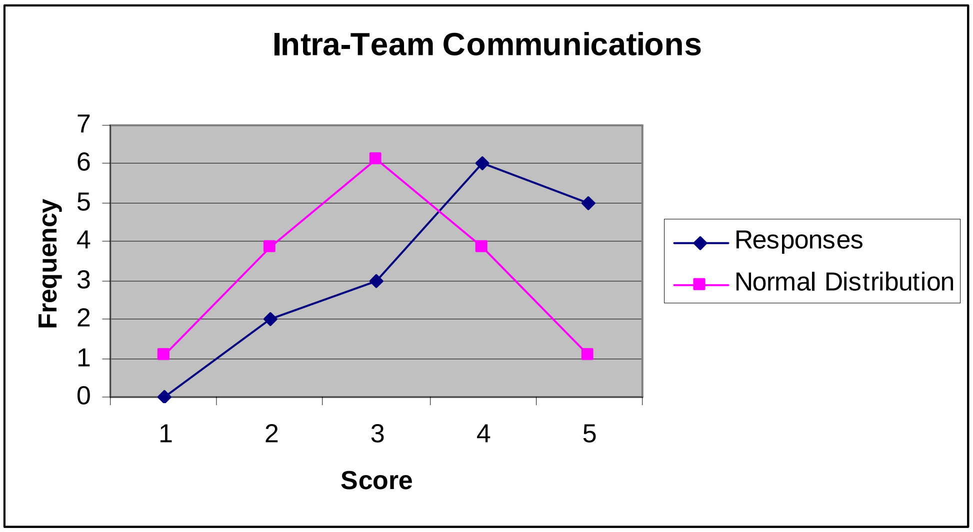

Figure 14: Responses to Intra-Team Communications vs. Normal Distribution

Table 20
t-Test: Paired Two Sample for Means of Intra-Team Communications vs. Normal Distribution

	Intra-Team Comms	*Normal Dist*
Mean	3.875	3
Variance	1.05	1.06666667
Observations	16	16
Pearson Correlation	-0.31497039	
Hypothesized Mean Difference	0	
df	15	
t Stat	2.097903145	
P(T<=t) one-tail	0.026632475	
t Critical one-tail	1.753051038	

The t-value is large enough for the responses to Intra-Team Communications to be statistically significant compared to a normal distribution.

4. Tactical Awareness. The average of the responses to the question, "How useful do you think the Tactical Decision-making Simulation was in providing an opportunity for students to improve on tactical awareness to execute the mission?" was 3.88. See Figure 15 for a comparison of responses to the expected responses in a normal distribution. Table 21 displays the results of the t-Test.

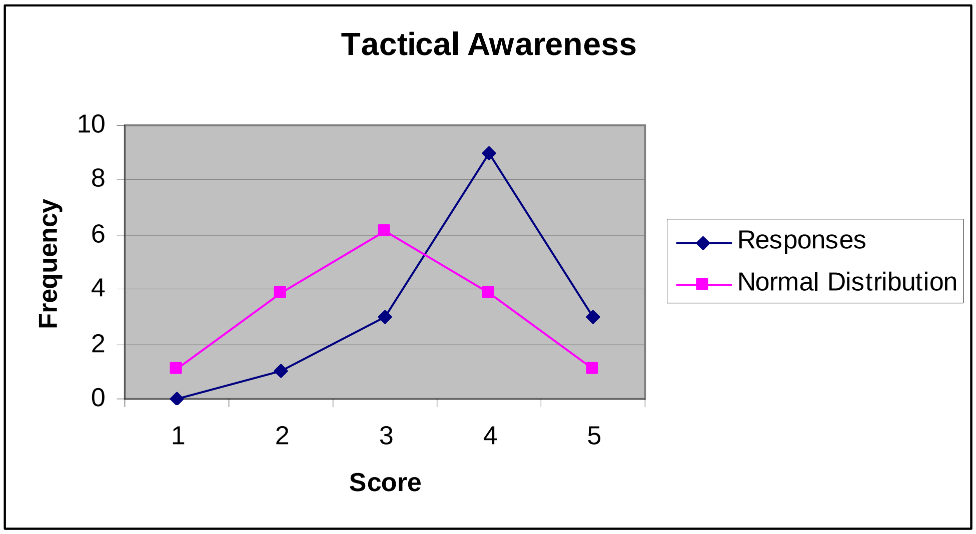

Figure 15: Responses to Tactical Awareness vs. Normal Distribution

Table 21
t-Test: Paired Two Sample for Means of Tactical Awareness vs. Normal Distribution

	Tactical Awareness	*Normal Dist*
Mean	3.875	3
Variance	0.65	1.06666667
Observations	16	16
Pearson Correlation	0.240192231	
Hypothesized Mean Difference	0	
df	15	
t Stat	3.050212692	
P(T<=t) one-tail	0.004049976	
t Critical one-tail	1.753051038	

The t-value is large enough for the responses to Tactical Awareness to be statistically significant compared to a normal distribution.

5. Movement Techniques. The average of the responses to the question, “How useful do you think the Tactical Decision-making Simulation was in providing an opportunity for students to improve on movement techniques to execute the mission?” was 3.69. See Figure 16 for a comparison of responses to the expected responses in a normal distribution. Table 22 displays the results of the t-Test.

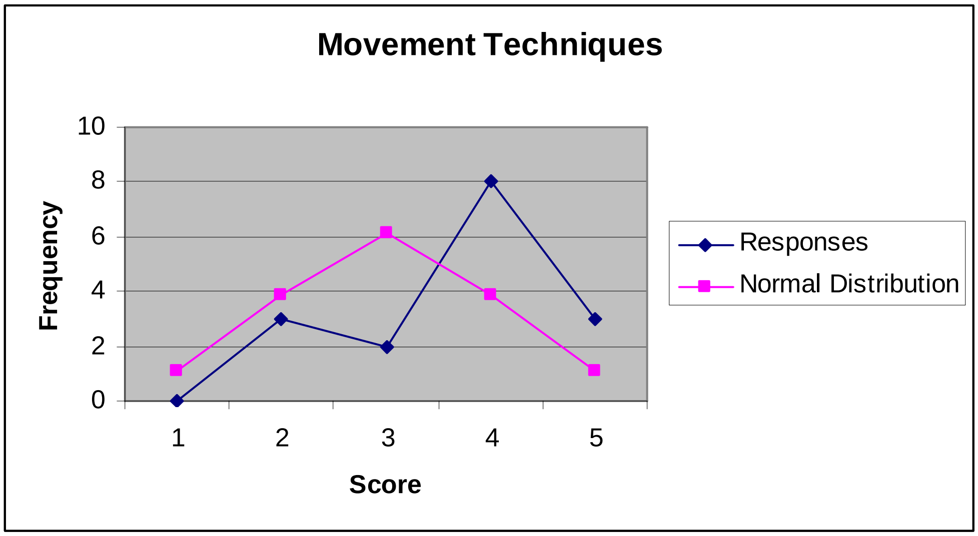

Figure 16: Responses to Movement Techniques vs. Normal Distribution

Table 22
t-Test: Paired Two Sample for Means of Movement Techniques vs. Normal Distribution

	Movement Techniques	*Normal Dist*
Mean	3.6875	3
Variance	1.029166667	1.06666667
Observations	16	16
Pearson Correlation	0.063628476	
Hypothesized Mean Difference	0	
df	15	
t Stat	1.963034178	
P(T<=t) one-tail	0.034230477	
t Critical one-tail	1.753051038	

The t-value is large enough for the responses to Movement Techniques to be statistically significant compared to a normal distribution.

6. Weapons Employment. The average of the responses to the question, “How useful do you think the Tactical Decision-making Simulation was in providing an opportunity for students to improve on weapons employment to execute the mission?” was 3.06. See Figure 17 for a

comparison of responses to the expected responses in a normal distribution. Table 23 displays the results of the t-Test.

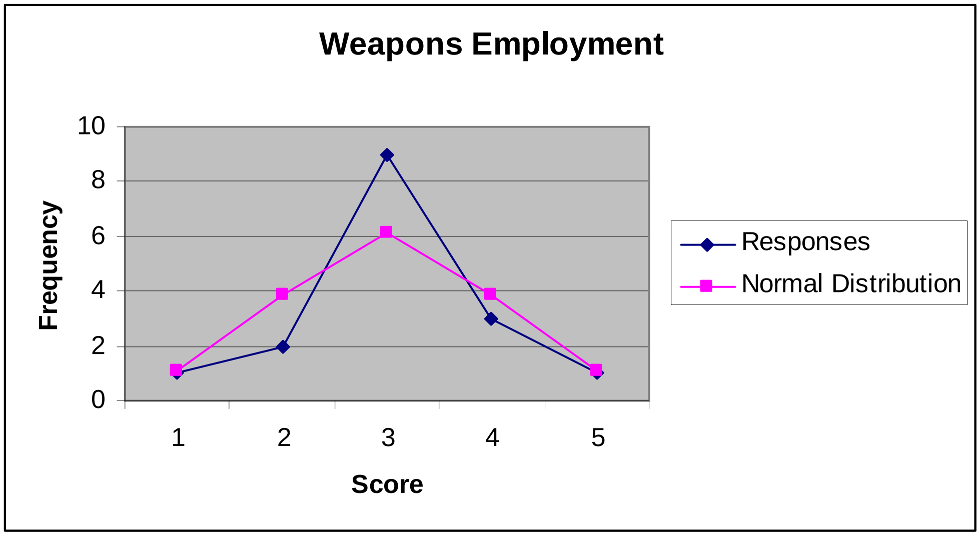

Figure 17: Responses to Weapons Employment vs. Normal Distribution

Table 23
t-Test: Paired Two Sample for Means of Weapons Employment vs. Normal Distribution

	Weapons Employment	*Normal Dist*
Mean	3.0625	3
Variance	0.8625	1.06666667
Observations	16	16
Pearson Correlation	0.069504805	
Hypothesized Mean Difference	0	
df	15	
t Stat	0.186555043	
P(T<=t) one-tail	0.427254589	
t Critical one-tail	1.753051038	

The t-value is not large enough for the responses to Weapons Employment to be statistically significant compared to a normal distribution.

7. Rules of Engagement. The average of the responses to the question, “How useful do you think the Tactical Decision-making Simulation was in providing an opportunity for students to

improve on rules of engagement to execute the mission?" was 3.13. See Figure 18 for a comparison of responses to the expected responses in a normal distribution. Table 24 displays the results of the t-Test.

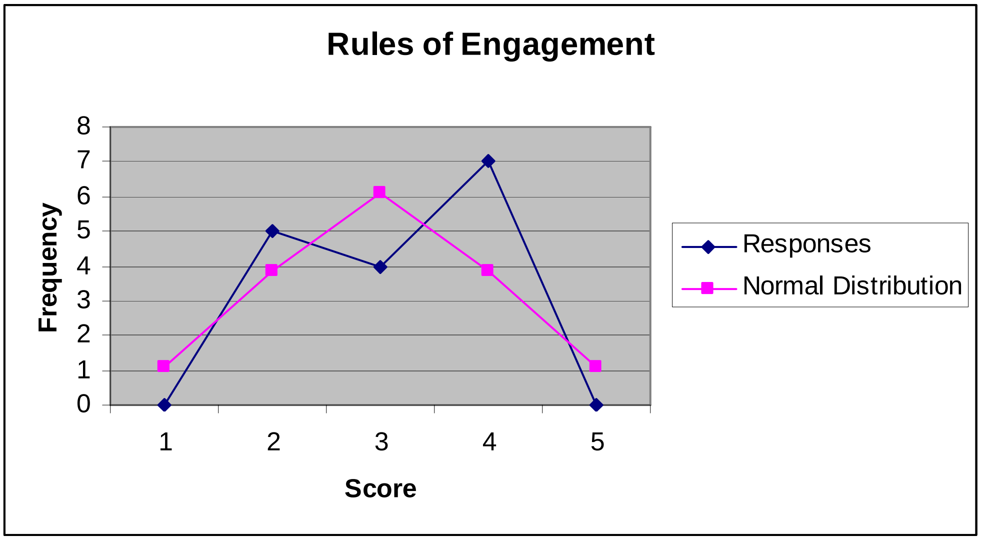

Figure 18: Responses to Rules of Engagement vs. Normal Distribution

Table 24
t-Test: Paired Two Sample for Means of Rules of Engagement vs. Normal Distribution

	Rules of Engagement	*Normal Dist*
Mean	3.125	3
Variance	0.783333333	1.06666667
Observations	16	16
Pearson Correlation	0.291729983	
Hypothesized Mean Difference	0	
df	15	
t Stat	0.43574467	
P(T<=t) one-tail	0.334613749	
t Critical one-tail	1.753051038	

The t-value is not large enough for the responses to Rules of Engagement to be statistically significant compared to a normal distribution.

These tests tell us that the Marine students, who had already spent 3 ½ weeks in the CQB Course, felt that the TDS provided an opportunity for the students to improve their skills in Situational Awareness, Intra-Team Communications, Tactical Awareness, and Movement Techniques in a statistically significant manner. We can relate these directly back to the four TDS-related items from the Tactical Evaluation that are in the assault phase that was practiced in F2F: “Proper Hallway Assessment / Coordination” (Situational Awareness, Intra-Team Communications), “Conducts Proper 5 Step Entry” (Tactical Awareness, Movement Techniques), “Maintains Tactical Advantage / IBT” (Situational Awareness, Tactical Awareness), and “Stairwell Up / Down” (Tactical Awareness, Movement Techniques).

With this revelation in mind, let us look at one more Mann-Whitney Test. This examination again includes only the twenty-four Marines of the test population who did not fail the course because of safety infractions. We look only at the scoring aspects corresponding to those areas judged by the Marines to be most valuable for improving their skills. In this case, the raw scores can only vary between 88 and 100. The individual activity scores can be seen in Appendix I. Table 25 shows the results of the Mann-Whitney test for $n_a = 14$; $n_b = 10$:

Table 25
Mann-Whitney Test for Assault Phase TDS-Related Scores of 24 Marines without Safety Failures

	Ranks			Scores	
	Experimental Group	Control Group		Experimental Group	Control Group
1	6.5	2.5		94	93
2	13	13		95	95
3	13	6.5		95	94
4	1	19.5		92	96
5	13	6.5		95	94
6	13	2.5		95	93
7	19.5	19.5		96	96
8	23	13		97	95
9	19.5	6.5		96	94
10	24	19.5		98	96
11	6.5			94	
12	6.5			94	
13	19.5			96	
14	13			95	
Sum:	191.0	109.0	Avg:	95.14	94.6

The sum of the ranks for the Experimental Group, T_A = 191.0. $T_{A[max]}$ = 245. The difference between T_A and $T_{A[max]}$ (U_A) is 54. Based on the table of critical values of U for n_a = 14; n_b = 10, the lower limit for a .05 level of significance for a directional test is 41. In order to reject the null hypothesis, the value of T_A would have to be less than 41. Therefore, while even closer still than the previous examination, the null hypothesis cannot be rejected for this examination.

To confirm this result, the Chi Square Test follows in Table 26 (excerpted):

Table 26
Chi Square Test for Assault Phase TDS-Related Scores of 24 Marines without Safety Failures

Total Score:	98	97	96	95	94	93	92
Experimental Group	1	1	3	5	3	0	1
Experimental Group Expected	0.6	0.6	3.5	4.1	3.5	1.2	0.6
Experimental Group Chi Square	0.3	0.3	0.1	0.2	0.1	1.2	0.3
Control Group	0	0	3	2	3	2	0
Control Group Expected	0.4	0.4	2.5	2.9	2.5	0.8	0.4
Control Group Chi Square	0.4	0.4	0.1	0.3	0.1	1.6	0.4
Total	1	1	6	7	6	2	1

Total Chi Square = 5.78; Degrees of Freedom = 12; Critical Value (.05) = 21.026. We cannot reject the null hypothesis.

Finally, we will look at these four TDS-related items individually. First is “Proper Hallway Assessment / Coordination.” Unfortunately almost every Marine in both the control and experimental groups lost the maximum points on this so any evaluation would be pointless. In fact, only one Marine out of the entire class received any points for this item.

Moving to the next item, “Conducts Proper 5 Step Entry,” the experimental group scored a combined 80% compared to the control group’s 66%. This examination includes only the twenty-four Marines of the test population who did not fail the course because of safety infractions. We look only at the scoring aspects corresponding to the “Conducts Proper 5 Step Entry.” The individual activity scores can be seen in Appendix I. Table 27 shows the results of the Mann-Whitney test for $n_a = 14$; $n_b = 10$:

Table 27
Mann-Whitney Test for "Conducts Proper5-Step Entry" Scores of 24 Marines without Safety Failures

	Ranks			Scores	
	Experimental Group	**Control Group**		**Experimental Group**	**Control Group**
1	7	7		3	3
2	7	15.5		3	4
3	21.5	1		5	2
4	7	7		3	3
5	7	7		3	3
6	7	15.5		3	4
7	21.5	7		5	3
8	21.5	7		5	3
9	21.5	15.5		5	4
10	21.5	15.5		5	4
11	7			3	
12	15.5			4	
13	15.5			4	
14	21.5			5	
Sum:	202	98	Avg:	4.0	3.3

The sum of the ranks for the Experimental Group, T_A = 202.0. $T_{A[max]}$ = 245. The difference between T_A and $T_{A[max]}$ (U_A) is 43. Based on the table of critical values of U for n_a = 14; n_b = 10, the lower limit for a .05 level of significance for a directional test is 41. In order to reject the null hypothesis, the value of T_A would have to be less than 41. Therefore, although it is extremely close, the null hypothesis cannot be rejected for this examination.

To confirm this result, the Chi Square Test (excerpted) is shown in Table 28:

Table 28
Chi Square Test for "Conducts Proper5-Step Entry" Scores of 24 Marines without Safety Failures

Total Score:	5	4	3	2
Experimental Group	6	2	6	0
Experimental Group Expected	3.5	3.5	6.4	1.4
Experimental Group Chi Square	1.8	0.6	0	1.4
Control Group	0	4	5	1
Control Group Expected	2.5	2.5	4.6	0.4
Control Group Chi Square	2.5	0.9	0	0.8
Total	6	6	11	1

Total Chi Square = 5.83; Degrees of Freedom = 5; Critical Value (.05) = 11.07. We cannot reject the null hypothesis.

Moving to the third item, "Maintains Tactical Advantage / IBT," the experimental group scored a combined 50% compared to the control group's 56.7%. This examination includes only the twenty-four Marines of the test population who did not fail the course because of safety infractions. We look only at the scoring aspects corresponding to the "Maintains Tactical Advantage / IBT." The individual activity scores can be seen in Appendix I. Table 29 shows the results of the Mann-Whitney test for $n_a = 14$; $n_b = 10$:

Table 29
Mann-Whitney Test for "Maintains Tactical Advantage / IBT" Scores of 24 Marines without Safety Failures

	Ranks			**Scores**	
	Experimental Group	**Control Group**		**Experimental Group**	**Control Group**
1	8	7		1	0
2	22	15.5		3	1
3	2.5	1		0	2
4	8	7		1	3
5	15.5	7		2	3
6	15.5	15.5		2	0
7	8	7		1	3
8	15.5	7		2	2
9	15.5	15.5		2	1
10	22	15.5		3	2
11	8			1	
12	8			1	
13	15.5			2	
14	2.5			0	
Sum:	166.5	133.5	Avg:	1.5	1.7

The sum of the ranks for the Experimental Group, $T_A = 166.5$. $T_{A[max]} = 245$. The difference between T_A and $T_{A[max]}$ (U_A) is 78.5. Based on the table of critical values of U for $n_a = 14$; $n_b = 10$, the lower limit for a .05 level of significance for a directional test is 41. In order to reject the null hypothesis, the value of T_A would have to be less than 41. Therefore, the null hypothesis cannot be rejected for this examination. In actuality, the control group scored slightly better than the experimental group on this task. However, the upper limit for a .05 level of significance for a directional test is 99. For the opposite effect to have been true (that the control group scored significantly better than the experimental group), the value of T_A would have to be greater than 99. Therefore, the null hypothesis still cannot be rejected.

To confirm this result, the Chi Square Test (excerpted) is shown in Table 30:

Table 30
Chi Square Test for "Maintains Tactical Advantage / IBT" Scores of 24 Marines without Safety Failures

Total Score:	5	4	3	2
Experimental Group	6	2	6	0
Experimental Group Expected	3.5	3.5	6.4	1.4
Experimental Group Chi Square	1.8	0.6	0	1.4
Control Group	0	4	5	1
Control Group Expected	2.5	2.5	4.6	0.4
Control Group Chi Square	2.5	0.9	0	0.8
Total	6	6	11	1

Total Chi Square = 0.75; Degrees of Freedom = 3; Critical Value (.05) = 7.815. We cannot reject the null hypothesis.

Finally, in the fourth item, "Stairwell," the experimental group scored a combined 82.14% compared to the control group's 70.0%. This examination includes only the twenty-four Marines of the test population who did not fail the course because of safety infractions. We look only at the scoring aspects corresponding to the "Stairwell." The individual activity scores can be seen in Appendix I. Table 31 shows the results of the Mann-Whitney test for $n_a = 14$; $n_b = 10$:

Table 31
Mann-Whitney Test for "Stairwell" Scores of 24 Marines without Safety Failures

	Ranks			**Scores**	
	Experimental Group	**Control Group**		**Experimental Group**	**Control Group**
1	16.5	16.5		2	2
2	6	16.5		1	2
3	16.5	16.5		2	2
4	2	16.5		0	2
5	16.5	2		2	0
6	16.5	6		2	1
7	16.5	2		2	0
8	16.5	16.5		2	2
9	6	6		1	1
10	16.5	16.5		2	2
11	16.5			2	
12	6			1	
13	16.5			2	
14	16.5			2	
Sum:	185	115	Avg:	1.64	1.4

The sum of the ranks for the Experimental Group, T_A = 185. $T_{A[max]}$ = 245. The difference between T_A and $T_{A[max]}$ (U_A) is 60. Based on the table of critical values of U for n_a = 14; n_b = 10, the lower limit for a .05 level of significance for a directional test is 41. In order to reject the null hypothesis, the value of T_A would have to be less than 41. Therefore, the null hypothesis cannot be rejected for this examination.

To confirm this result, the Chi Square Test (excerpted) is shown in Table 32:

Table 32
Chi Square Test for "Stairwell" Scores of 24 Marines without Safety Failures

Total Score:	2	1	0
Experimental Group	10	3	1
Experimental Group Expected	9.3	2.9	4.2
Experimental Group Chi Square	0	0	2.4
Control Group	6	2	2
Control Group Expected	6.7	2.1	1.3
Control Group Chi Square	0.1	0	0.5
Total	16	5	3

Total Chi Square = 0.114; Degrees of Freedom = 2; Critical Value (.05) = 5.99. We cannot reject the null hypothesis.

Turning back to the questionnaires, while there is not enough evidence to prove a correlation, it is interesting to note that when the Post-Experiment Questionnaires from the two Marines from the experimental group who had been dropped from the class are eliminated from the calculations (see Table 33), the average scores in all seven categories increase!

Table 33
Post-Experiment Questionnaire Results without Tactical Evaluation Safety Violation Failures

	Planning	Situational Awareness	Intra-Team Comms	Tactical Awareness	Movement Techniques	Weapons Employ-ment	Rules of Engage-ment
Avg:	3.64	3.86	3.93	4.00	3.79	3.07	3.21

In fact, this increase causes the t-value to become large enough for the responses to Planning to be statistically significant compared to a normal distribution (see Table 34).

Table 34
t-Test: Paired Two Sample for Means of Planning vs. Normal Distribution without Tactical Evaluation Failures

	Planning	*Normal Dist*
Mean	3.64285714	3
Variance	0.55494505	0.96153846
Observations	14	14
Pearson Correlation	0.47387177	
Hypothesized Mean Difference	0	
df	13	
t Stat	2.64952826	
P(T<=t) one-tail	0.01001486	
t Critical one-tail	1.7709317	

Also interesting is the correlation between the Tactical Evaluation tactical scores of the top five Experimental Group Marines (all scoring in the 90s) and their Questionnaire scores as compared to the rest of the experimental group (see Table 35).

Table 35
Comparison between Tactical Evaluation scores and Post-Exercise Questionnaire

Top 5 TacEval Scorers' Average	Post-Exercise Questionnaire Average		All other TacEval Scorers' Average (excluding fails)	Post-Exercise Questionnaire Average
93	28.6		86.667	23.777

Perhaps counter-intuitively, at least on the surface, the Marines who stated on the demographics questionnaire that they play First Person Shooter games "regularly" did not estimate the TDS to be quite as useful as the top five Tactical Evaluation scorers, nor did they score as highly on the Tactical Evaluation (see Table 36). However, based on my experience with TDSs, gamers tend to "game the game" whereas the TDSs are designed for the Marines to practice their real-world TTPs, so these results are not surprising.

Table 36
Comparison between Regular FPS players and the top 5 Tactical Evaluation Scorers

Regular "First Person Shooter" players' Average (excluding fails)	Post-Exercise Questionnaire Average		Top 5 TacEval Scorers' Average	Post-Exercise Questionnaire Average
88.6	28		93	28.6

CHAPTER FIVE: CONCLUSION

Summary

The purpose of this research was to evaluate the training transfer associated with a Tactical Decision-making game, using *Close Combat: First to Fight* as a case study. The null hypothesis that was tested was that traditional field training is equivalent to virtual training combined with field training. Measurements of the subjects' performance in live training were recorded. Additionally, self assessment questionnaires were administered. This experimentation compared, assessed, and reported on training value achieved through traditional field training versus the benefits of virtual training combined with field training. In order to explore this question a field experiment was conducted using the *Close Combat: First to Fight* software to train sixteen Marines in the tactical tasks associated with Close Quarters Battle. The extent of the training using the simulation involved one familiarization session for approximately 45 minutes and two training sessions with eight Marines in each two-hour session.

Conclusions

The experimental group numerically outscored and appeared to outperform the control group on the live fire Tactical Evaluation. The differences in measured performance during the live exercise between the control group and experimental group approached statistical significance.

Self-assessment evaluations did result in statistically significant results. Marines in the experimental group felt that the TDS provided an opportunity for the students to improve their skills in Situational Awareness, Intra-Team Communications, Tactical Awareness, and Movement Techniques in a statistically significant manner. This is consistent with prior self assessment evaluations on games.

These positive areas of self-assessments arising from practice in F2F can be directly related back to a subset of four performance measures in the assault phase of the Tactical Evaluation. They are “Proper Hallway Assessment / Coordination” (Situational Awareness, Intra-Team Communications), “Conducts Proper 5 Step Entry” (Tactical Awareness, Movement Techniques), “Maintains Tactical Advantage / IBT” (Situational Awareness, Tactical Awareness), and “Stairwell Up / Down” (Tactical Awareness, Movement Techniques). Statistical analysis of these four measures in aggregation and individually revealed that the experimental group did not perform statistically different from the control group.

Some possible explanations for the lack of statistical differences in terms of the performance portion of this research, in order of importance, include:

- Insufficient training time. The last-minute reduction in training time allotted to the TDS resulted in only a two-hour intervention in a four-week, 160+ hour course of instruction. This relatively minor training period, being such a small percentage of the overall course, had little opportunity to make a statistical impact.
- Insufficient confidence in the method of instruction on the part of the instructors. Without evidence of the validity of the type of training that this experiment was designed to demonstrate, instructors were hesitant to devote themselves in the full measure required to conduct proper training (scenario preparation, briefing, mentoring, and debriefing).
- Insufficient ability of the simulation to represent real world physical interactions. In a CQB environment, where darkness and noise may impede visual and auditory communication, physical interaction becomes vital. Among these are “stacking,” the “leg bump,” “dead checks,” and the Hostages, Unidentified, Terrorists, and Shooters (HUTS) report.

- Stacking: Before entering a room, Marines line up outside the door (see Figure 19). Each Marine in the stack has a specific task, based on his position in the stack, once inside the room. Because of an issue with collision detection in the game, the Marines had a difficult time stacking before entering rooms that were to be cleared. This issue is the result of the method of application of “bounding boxes” in the software.

Figure 19: CQB Marines in the Stack

- Leg bump: When Marines encounter a situation (such as clearing a room) that requires multiple Marines to act together, the number two man in the stack uses his knee to bump the lead Marine in his hamstring to signify that the team is ready to execute. The number two man normally also announces the number of Marines in the stack so that the lead Marine knows what tactics are to be employed (tactical responsibilities inside the room to be cleared are dependent on the number of Marines entering). Without the physical bump, the verbal announcement of “You’ve got two!” or “You’ve got three!” was the only way to replicate this action.

Figure 20: CQB Marines Entering a Room

- Dead check: After clearing a room, the Marines conduct a “dead check” on any terrorists that have been shot to ensure that they are dead. This consists of sweeping the body for weapons and performing an “eye thump,” thumping the eyeball with a finger to check for any reaction. There is no procedure for replicating this in the TDS and it must be assumed that any terrorists that are down are dead.
- HUTS report: After clearing the assigned area, the team consolidates and the team leader touches each Marine on the head (who then kneels down) to get an accurate accounting of the “Shooters.” This is followed by each Marine holding up a hand with the number of fingers extended representing the number of dead terrorists personally checked, with the team leader touching each Marine’s hand to get a

physical count of dead terrorists. Again, there is no procedure for replicating this in the TDS and convey the information verbally.

Lessons Learned

1. Game Selection

The personal computer-based game to be used for training must be very carefully selected to ensure that it satisfies not only the training goals but also the organization of and equipment used by the trainees. In the case of this research, the original intent was to conduct the experiment using a traditional Marine Corps Rifle Squad conducting MOUT. This is where the game F2F truly shines. However, the experiment was actually conducted with the MCSF Training Company conducting CQB. Because the terms MOUT and CQB are tossed about so casually and almost interchangeably, the important differences between the two and how they would affect the experiment were not captured before the conduct of the experiment.

While MOUT can involve a wide range of operations, from patrolling to full combat, it tends to encompass tactics at the high-intensity end of the scale. Marine Rifle Squads, as part of a larger force, are called upon to plan and evaluate possible tactical operations consisting of street clearing and building clearing with a great deal of force, often supported by combined arms (mortars, artillery, and aircraft). Based on prior research and self-assessment scores, F2F appears to be as suitable as similar games in planning, evaluating, and selecting from a wide set of possible small unit tactical operations. The CQB implementation of the room clearing operations, on the other hand, tends to deal more with execution of a well honed technique within the set of possible military operations in urban terrain. Emphasis on execution of a specific technique much of which is not addressed by the game undermines its ability to directly contribute to success. Operations at a lower scale of combat, such as physical room clearing that entail so many actual physical behaviors do not appear to be supported by this desktop game. Additionally, “stacking” and “bumping” are vital aspects of CQB training. Neither of these is supported by F2F.

Another lesson learned is that the training should have been more consistent with the actual field trial. The Marine Rifle Squad is composed of thirteen Marines—three fire teams plus the squad leader. In the actual experiment, a MCSF team was used. These teams can vary from two to eight Marines and fluctuate even during an operation. During the training, teams of eight Marines were used; during testing, teams of four (one student and three instructors) were used.

Further, players were equipped with weapons that were different in the training than in the actual field trial. The primary weapons of the rifle squad are seven M-16 rifles, three M-209 grenade launchers (M-16 rifles with grenade launchers attached), and three M-249 squad automatic weapons. The primary weapon of MCSF personnel is the M-4 rifle (similar to the M-16 but with a shorter stock) (see Figures 21 and 22). Each also carries an M-9 pistol as a back-up weapon, which is not accommodated in the F2F game.

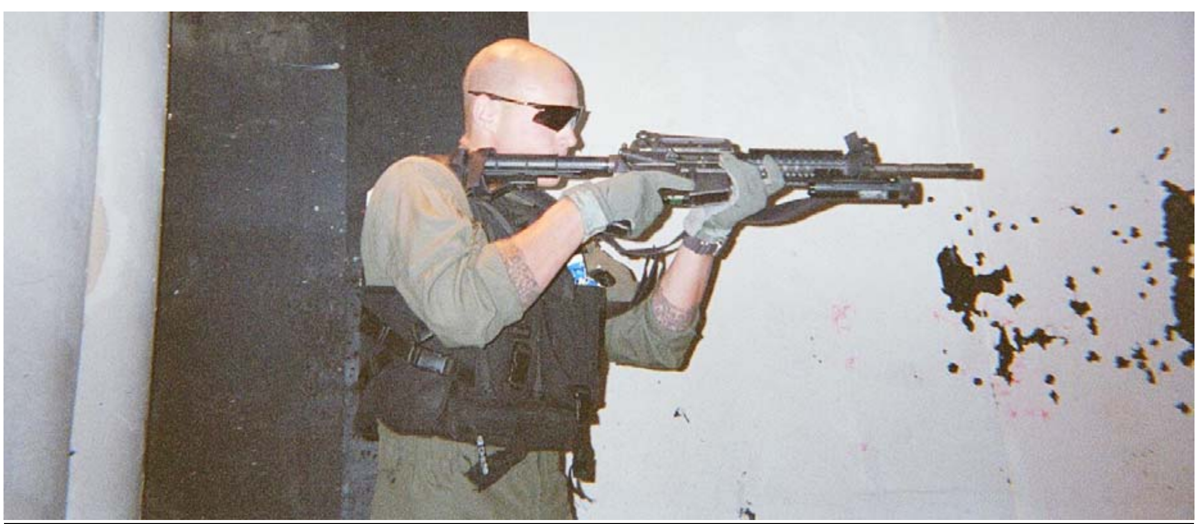

Figure 21: CQB Marine with M-4 Rifle

2. Know the software

While I was quite familiar with Close Combat: First to Fight, there was one setting that I was unaware of that impacted the training. I was unable to have all avatars in the training sessions use M-16 rifles, so some had to use M-209 grenade launchers (with instructions to use only the rifle aspect and not the grenade launcher), some had to use shotguns (which are used occasionally in MCSF tactics) and some had to use AK-47 rifles (little real difference in terms of game play but very different in appearance). With the "work arounds" there was no significant difference in the training conducted but there was a slight alteration in the mind set.

3. Computer Set-Up

Never trust a contractor to deliver on time! Depending on a contractor to ship four computers to the experimentation facility almost sank the experiment. Had I not bee able to rent computers locally to conduct the experiment (or had I not allowed enough time for such contingencies), the experiment could not have been conducted.

As a consequence of being two computers short of the planned configuration, I was unable to interject non-combatants into the training scenarios. The low Post-Exercise Questionnaire score for Rules of Engagement is undoubtedly directly attributable to this fact.

4. Keep the experimentation paperwork organized

One form that was completed by the test subjects (post exposure checklist) did not have the subject's identification number on it which required matching the forms together after the fact.

5. Abide by the three-phase training rule

- Mission brief and planning
- Execution

- After Action Review

Because the instructors were unfamiliar with conducting a training exercise using a PC game, I initially had to lead this effort. Once the instructors picked up on it and felt more comfortable, they were able to jump in.

Recommendations for Further Research

I believe that a similarly conducted research project should be performed at the USMC School of Infantry, Camp Geiger, North Carolina, to examine the use of *Close Combat: First to Fight* for training a standard Marine Corps rifle squad. The hypothesis of this recommended future research would be similar to the hypothesis of the research presented in this report. However, there are many conditions that vary. This research project would have the support of the USMC Training and Education Command, located in Quantico, Virginia.

There are several reasons that I feel this would ultimately produce better results:

- Sufficient training time. The School of Infantry has much greater experience with TDSs and would be better suited to incorporate a TDS into the regular curriculum, providing much more training time with the simulation throughout the curriculum. This would allow a much higher likelihood of demonstrating a statistically significant improvement in training.
- Sufficient confidence in the method of instruction on the part of the instructors. School of Infantry instructors have seen evidence (although not scientific) of the validity of the type of training that this experiment was designed to demonstrate and will be much less hesitant to devote themselves in the full measure required to

conduct proper training (scenario preparation, briefing, mentoring, and debriefing).

- Sufficient ability of the simulation to represent real world interactions. Without the need for the extreme physical interactions of CQB, the TDS should be capable of handling a broader range of tasks. F2F is designed around a standard USMC fire team which is the basis of much of the training at the School of Infantry.

Further, there are additional items of detailed research that should be undertaken based upon observations made during this experiment.

- Differences between regular gamers versus gaming novices on relative performance in real world tasks after game-based training.
- The effect of instructor bias on game-based training.
- Attitudes of trainees and instructors towards game-based training before the training, after the training, and after the experiment's evaluation.

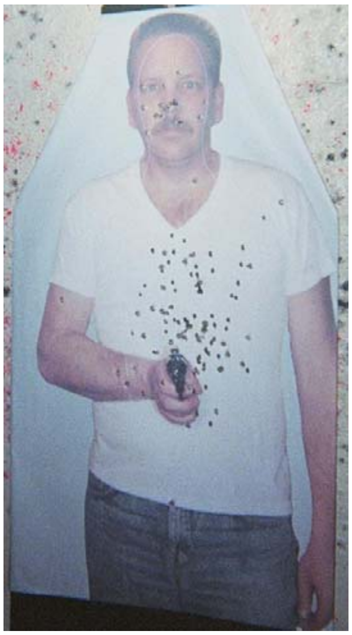

Figure 22: The Drawbacks of being the Bad Guy!

APPENDIX A: PROJECT METROPOLIS

A team of researchers under the direction of Captain J. E. Smith, USMC conducted a technology demonstration and data collection effort with members of the 3rd Battalion, 4th Marines (3/4) and supporting forces from Marine Corps Base Twentynine Palms, California. This unit was participating in the MCWL's Project Metropolis at the former George Air Force Base in Victorville, California. One phase of Project Metropolis focuses on technology applications and MOUT training. Prior to the demonstration, the research team selected and set up a networked sixteen-PC (desktop) system running Rogue Spear: Urban Operations in the multi-player mode. Several different scenarios (mission areas and locations) were selected for use.

The demonstration was set up in three shifts of three hours each. One partial squad (eight Marines) from 1st Platoon, India Company 3/4 participated in each shift as "Blue" Forces (BLUFOR) and Marines from the Combat Service Support Detachment participated as the Opposing Forces (OPFOR).

The first day was essentially a training day. Each Marine completed a profile and was afforded an opportunity to learn to operate the game controls and key commands and generally become familiar with maneuvering and performing various actions: running, squatting, shooting, climbing, opening doors, employing secondary weapons, etc.

On the second day each squad leader was given a mission (attack or defend) in a designated area within the selected scenario. The philosophy was to give the squad leaders an opportunity to issue an operation order to the squad, carry out a reconnaissance, and execute the mission. Missions normally had a time limit of twenty minutes but would often end sooner with one team having no survivors. The platoon sergeant and platoon commander also spent a considerable amount of time either participating as a squad member in the game or providing feedback and coaching the squad leaders and squad members. Additionally, the company commander spent about eight hours observing during the week and the battalion commander and sergeant major spent about two hours observing, returning on the fifth day with a visiting U.S. Senatorial staff member.

One unexpected difficulty encountered was that the Marines, during the reconnaissance walk-through, would often go off on their own to explore and often shoot the other squad's players. This was counter-productive, so on the third day the procedure was altered somewhat. At the beginning of each reconnaissance session, the squad leader would shoot all of his squad members. They could then toggle their screen views to the squad leader's point of view and they could all see the same thing under the squad leader's control.

At the end of the third day, the research team determined that the Local Area Network (LAN) could be split into two networks on the fly. This resulted in another change to the procedures on the fourth day of the demonstration; the LAN would be split for the reconnaissance walk-through, which prevented the Marines from shooting at each other. With no opposing players visible, the squads were able to conduct reconnaissance and to try various strategies. It was noted that that most of the squad leaders (squad members often rotated as squad leader) had limited experience in developing fragmentary operation orders. Various members of the platoon and the research team (all former/retired military) began coaching them in the process. Additionally, the platoon sergeant and platoon commander began using the sessions as a way to conduct training in the techniques and skills of maneuvering. Initially, these two factors were viewed as observer interference but later formed the basis of vitally important aspect of the video game: that the game provides a virtual training area and that the platoon leadership provides the training and feedback as they would in a field training evolution.

On the final day, a major change in the process occurred based on the possibility that the trainer would be placed at the 3/4 headquarters for use as an experimental training lab for approximately six months. Only the infantry squads, rotating in and out in a series of round robin sessions, alternating between offense and defense, manned the lab. Each squad had a chance to play both roles in each of three mission areas. They were also given approximately 30 minutes (the time they were outside the rotation) to review their performance and to plan for their missions. The practice of splitting the LAN continued and a Mission Rehearsal session was incorporated to allow them to do a walk-through of their plan on the actual terrain of the mission. This led to a significant improvement in team execution and overall performance. The platoon sergeant and platoon commander continued to provide training guidance during the planning process. During the afternoon, the Combat Service Support teams were afforded the same opportunity, with the research team members providing training guidance.

At the completion of each of these evolutions, a formal data collection session was conducted using an evaluation instrument titled “Post-Game Debrief Survey”. Written comments were highly encouraged and a period for verbal comments was conducted. At the completion of the Project Metropolis MOUT field exercises, a second formal data collection session was conducted using an evaluation instrument titled “Post-Exercise Survey”. Again, written comments were highly encouraged.

The Marines participating in the demonstration ranged in age from 18 to 33, with an average age of 21. They had from one to ten years of service, with an average of 2.1 years. There were fifteen privates first class, 14 lance corporals (plus one corpsman), ten corporals, three sergeants, one staff sergeant, and one second lieutenant.

The Marines’ responses to the post-game debrief survey instrument (averages):

How adequate was the quality of the realism of the game (resolution, graphics, sound) for you to execute your mission? 4.31

How adequate were the maps for you to execute your mission? 3.92

Key: 1 = Very inadequate, 2 = Inadequate, 3 = Borderline Adequate, 4 = Generally Adequate, 5 = More than Adequate

How useful do you think the (PC-based game) training system was in providing an opportunity for the team to improve on these skills to execute your mission(s):

Planning	4.36
Intra-Team Communications	4.13

Tactical Awareness	3.97
Movement Techniques	3.87
Weapons Employment/Fire Discipline	4.05

How useful do you think this (PC-based game) training system will be for improving your abilities in MOUT? 3.74

The Marines' responses to the post-exercise survey instrument (averages):

How useful do you think the (PC-based game) training system was in improving your, or the participants', overall ability/performance in MOUT?

4.13

How useful do you think the (PC-based game) training system was in improving your, or the participants', specific MOUT skills?

Planning	3.60
Intra-team Communications	3.95
Tactical Awareness	3.93
Movement Techniques	3.85
Weapons Employment/Fire Discipline	3.55

Key: 1 = Not at all useful, 2 = Not useful, 3 = Somewhat useful, 4 = Useful, 5 = Very useful

APPENDIX B: INFORMED CONSENT

Informed Consent

Please read this consent document carefully before you decide to participate in this study.

Project title: Cognitive Training Transfer using a Personal Computer-Based Game: A Close Quarters Battle Case Study

Purpose of the research study: To determine the effectiveness of games as a training system in achieving the desired transfer of skills to the actual environment.

What you will be asked to do in the study: You will participate in Close Quarters Battle training using a Tactical Decision-making Simulation (Game-based simulation).

Time required: 2 ½ hours during the Close Quarters Battle Course

Risks: Simulator Sickness.

Benefits/Compensation: Increased level of training / no monetary compensation.

Confidentiality: Your name will not be associated with the results of the study.

Voluntary participation: Yes, as part of the Close Quarters Battle Course.

Right to withdraw from the study: If you experience simulator sickness.

Whom to contact if you have questions about the study: Capt Peter Young, USMC, Officer in Charge

Whom to contact about your rights in the study: Michael D. Woodman

___________ I have read the procedure described above.

___________ I voluntarily agree to participate in the procedure.

____________________________________ / ____________________

Participant Date

APPENDIX C: DEMOGRAPHICS QUESTIONNAIRE

Demographics Questionnaire

1. ID __ __ __ __ (last 4 digits of SSN)

2. Rank: ___________

3. Age: ___________

4. MOS: ___________

5. Years in Service:

   USMC ___________

   Other ___________

6. Have you ever played the following types of videogames? Do you play them regularly?

   a. Role Playing Games ___ Yes ___ No ___ Yes ___ No

   b. Real Time Strategy Games ___ Yes ___ No ___ Yes ___ No

   c. First-person shooter games ___ Yes ___ No ___ Yes ___ No

   d. Others: ________________ ___ Yes ___ No ___ Yes ___ No

7. Before this experiment, have you ever played Close Combat: First to Fight?

   ___ Yes ___ No

8. Approximately how many hours a week do you play videogames?

   ________ hours

APPENDIX D: SIMULATOR SICKNESS QUESTIONNAIRE

Simulator Sickness Questionnaire (SSQ)

Developed by Robert S. Kennedy & colleagues under various projects. For additional information contact:

Robert S. Kennedy, RSK Assessments, Inc., 1040 Woodcock Road, Suite 227, Orlando, FL 32803 (407) 894-5090

ID (Last 4 digits of SSN): __ __ __ __ Date: ____________

PRE-EXPOSURE BACKGROUND INFORMATION

1. How long has it been since your last flight in an aircraft? _____ days
   How long has it been since your last voyage at sea? _____ days
   How long has it been since your last exposure in a virtual environment? _____ days

2. What experience have you had recently in a device with unusual motion?

PRE-EXPOSURE BACKGROUND INFORMATION

3. Are you in your usual state of fitness? (Circle one) YES NO
   If not, please indicate the reason:

4. Have you been ill in the past week? (Circle one) YES NO
   If "Yes", please indicate:
   a) The nature of the illness (Flu, cold, etc.):
   b) Severity of the illness: Very Mild _______________ Very Severe
   c) Length of illness: __________________ Hours / Days
   d) Major symptoms:
   e) Are you fully recovered? YES NO

5. How much alcohol have you consumed during the past 24 hours?
   ____ 12 oz. cans/bottles of beer ____ ounces wine ____ ounces hard liquor

6. Please indicate <u>all</u> medication you have used in the past 24 hours. If none, check the first line:
   a) NONE
   b) Sedatives or tranquilizers
   c) Aspirin, Tylenol, other analgesics
   d) Anti-histamines
   e) Decongestants
   f) Other (specify):

7. a) How many hours of sleep did you get last night? ____ hours
   b) Was this amount sufficient? (Circle one) YES NO

8. Please list any other comments regarding your present physical state that might affect your performance in our experiment.

APPENDIX E: BASELINE (PRE) EXPOSURE SYMPTOM CHECKLIST

Baseline (Pre) Exposure Symptom Checklist

Instructions: Please fill this out BEFORE you go into the virtual environment. Circle how much each symptom below is affecting you right now.

#	Symptom	Severity			
1.	General discomfort	None	Slight	Moderate	Severe
2.	Fatigue	None	Slight	Moderate	Severe
3.	Boredom	None	Slight	Moderate	Severe
4.	Drowsiness	None	Slight	Moderate	Severe
5.	Headache	None	Slight	Moderate	Severe
6.	Eye strain	None	Slight	Moderate	Severe
7.	Difficulty focusing	None	Slight	Moderate	Severe
8a.	Salivation increased	None	Slight	Moderate	Severe
8b.	Salivation decreased	None	Slight	Moderate	Severe
9.	Sweating	None	Slight	Moderate	Severe
10.	Nausea	None	Slight	Moderate	Severe
11.	Difficulty concentrating	None	Slight	Moderate	Severe
12.	Mental depression	None	Slight	Moderate	Severe
13.	"Fullness of the head"	None	Slight	Moderate	Severe
14.	Blurred Vision	None	Slight	Moderate	Severe
15a.	Dizziness with eyes open	None	Slight	Moderate	Severe
15b.	Dizziness with eyes closed	None	Slight	Moderate	Severe
16.	*Vertigo	None	Slight	Moderate	Severe
17.	**Visual flashbacks	None	Slight	Moderate	Severe
18.	Faintness	None	Slight	Moderate	Severe
19.	Aware of breathing	None	Slight	Moderate	Severe
20.	***Stomach awareness	None	Slight	Moderate	Severe
21.	Loss of appetite	None	Slight	Moderate	Severe
22.	Increased appetite	None	Slight	Moderate	Severe
23.	Desire to move bowels	None	Slight	Moderate	Severe
24.	Confusion	None	Slight	Moderate	Severe
25.	Burping	None	Slight	Moderate	Severe
26.	Vomiting	None	Slight	Moderate	Severe
27.	Other				

* Vertigo is experienced as loss of orientation with respect to vertical upright.
** Visual illusion of movement or false sensations of movement, when not in the simulator, car, or aircraft.
*** Stomach awareness is usually used to indicate a feeling of discomfort which is just short of nausea.

APPENDIX F: POST 00 MINUTES EXPOSURE SYMPTOM CHECKLIST

POST 00 Minutes Exposure Symptom Checklist

ID (Last 4 digits of SSN): _ _ _ _ **Date: _______________**

Instructions: Circle how much each symptom below is affecting you <u>right now</u>.

#	**Symptom**	**Severity**			
1.	General discomfort	None	Slight	Moderate	Severe
2.	Fatigue	None	Slight	Moderate	Severe
3.	Boredom	None	Slight	Moderate	Severe
4.	Drowsiness	None	Slight	Moderate	Severe
5.	Headache	None	Slight	Moderate	Severe
6.	Eye strain	None	Slight	Moderate	Severe
7.	Difficulty focusing	None	Slight	Moderate	Severe
8a.	Salivation increased	None	Slight	Moderate	Severe
8b.	Salivation decreased	None	Slight	Moderate	Severe
9.	Sweating	None	Slight	Moderate	Severe
10.	Nausea	None	Slight	Moderate	Severe
11.	Difficulty concentrating	None	Slight	Moderate	Severe
12.	Mental depression	None	Slight	Moderate	Severe
13.	"Fullness of the head"	None	Slight	Moderate	Severe
14.	Blurred Vision	None	Slight	Moderate	Severe
15a.	Dizziness with eyes open	None	Slight	Moderate	Severe
15b.	Dizziness with eyes closed	None	Slight	Moderate	Severe
16.	*Vertigo	None	Slight	Moderate	Severe
17.	**Visual flashbacks	None	Slight	Moderate	Severe
18.	Faintness	None	Slight	Moderate	Severe
19.	Aware of breathing	None	Slight	Moderate	Severe
20.	***Stomach awareness	None	Slight	Moderate	Severe
21.	Loss of appetite	None	Slight	Moderate	Severe
22.	Increased appetite	None	Slight	Moderate	Severe
23.	Desire to move bowels	None	Slight	Moderate	Severe
24.	Confusion	None	Slight	Moderate	Severe
25.	Burping	None	Slight	Moderate	Severe
26.	Vomiting	None	Slight	Moderate	Severe
27.	Other				

* Vertigo is experienced as loss of orientation with respect to vertical upright.
** Visual illusion of movement or false sensations of movement, when <u>not</u> in the simulator, car, or aircraft.
*** Stomach awareness is usually used to indicate a feeling of discomfort which is just short of nausea.

POST-EXPOSURE INFORMATION

1. While in the virtual environment, did you get the feeling of motion (i.e., did you experience a compelling sensation of self motion as though you were actually moving)? *(Circle one)*

YES NO SOMEWHAT

2. On a scale of 1 (POOR) to 10 (EXCELLENT) rate your performance in the virtual environment:

3. a. Did any unusual events occur during your exposure? *(Circle one)* YES NO
b. If YES, please describe

APPENDIX G: POST EXPERIMENT QUESTIONNAIRE

Post-Experiment Questionnaire

1. ID __ __ __ __ (last 4 digits of SSN)

2. Role: ___ Student ___ Instructor ___ Staff ___ Observer

3. What did you like about the Tactical Decision-making Simulation?

____
____
____

4. What did you dislike about the Tactical Decision-making Simulation?

____
____
____

5. What recommendations do you have for improving the Tactical Decision-making Simulation?

____
____
____
____
____

6. How useful do you think the Tactical Decision-making Simulation was in providing an opportunity for students to improve on these skills to execute the mission?

	Not at all useful	Not very useful	Neutral	Useful	Very Useful
Planning					
Situational Awareness					
Intra-Team Communications					
Tactical Awareness					
Movement Techniques					
Weapons Employment					
Rules of Engagement					

APPENDIX H: SUMMARY OF THE SURVEY OF PARTICIPANT DEMOGRAPHICS

Subj ID	Rank	Age	MOS	Years in Service		Role Playing Games		RTS Games		FPS Games		Others		CC: F2F	Hrs /
				USMC	Other	Ever	Regularly	Ever	Regularly	Ever	Regularly	Ever	Regularly	Ever	Week
7139	E3	20	0311	1.2	0	1	0	0	0	1	0			0	0
4451	E3	19	0311	1.5	0	1	1	1	1	1	0			0	20
4789	E3	19	0311	1	0	1	0	1	0	1	1			1	10
8203	E3	20	0311	1		1	1	1	1	1	1	1 (Racing)	1	1	10
6833	E2	21	0311	1		1	0	1	0	1	0			0	2
4920	E3	20	0311	1.5		0	0	0	0	1	0			0	1
9060	E3	22	0311	1		1	1	1	1	1	1			1	3
3692	E2	19	0311	1		1	0	1	0	1	0			1	1
2007	E3	19	0331	1.5		1	0	1	1	1	1	1 (Sports)	1	1	3.5
8476	E3	19	0311	1.4		1	0	0	0	1	0	0	0	0	0.5
0161	E3	19	0311	1		1	0	1	0	1	0			1	2
8573	E3	19	0311	1		1	0	1	0	1	0			1	1
5846	E2	19	0311	1		1		1		1				0	5
2085		19	0351	1.5		0	0	1	0	1	0	0	0	0	0
8927	E3	19	0311	1		1	0	1	1	1	1			1	4
4179	E3	20	0311	1.5		1	0	1	1	1	1	1	1	1	8
Average		19.56		1.19375	0	88%	20%	81%	40%	100%	40%	33%	60%	56%	4.4375

APPENDIX I: TACTICAL EVALUATION SCORES

Subject ID	Hallway Coord	5 Step Entry	Immed Action	Shot Delivery	Shot Placement	Door Check	Dead Check	Proper Marking	Tactical Advantage	Reload	Stairwell
7139	-2	-2					-1	-1	-2		
4451	-2	-2									-1
4789	-2		-1			-1	-1	-1	-3		
8203	-2	-2	-2			-1		-1	-2		-2
6833	-2	-2				-1		-1	-1		
4920	-2	-2					-2	-1	-1		
9060	-2						-1	-1	-2		
3692	-2		-2					-1	-1	-1	
2007	-2								-1		-1
8476											
0161	-2					-1	-1				
8573	-2	-2				-1	-2		-2		
5846	-2	-1					-1	-1	-2		-1
2085	-2	-1				-2	-2	-1	-1		
8927	-2					-1	-1		-3		
4179											
Control 1	-2	-2				-1	-2	-1	-3		
Control 2											
Control 3	-2	-1	-1			-1	-1		-2		
Control 4	-2	-3				-1	-2	-1	-1		
Control 5	-2	-2				-1	-1				
Control 6	-2	-2									-2
Control 7	-2	-1		-2		-1	-2		-3		-1
Control 8		-2									-2
Control 9	-2	-2			-8				-1	-1	
Control 10	-2	-1					-2		-2		-1
Control 11	-2	-1				-1		-1	-1		
Control 12											
Control 13											
Control 14											
Control 15											
Control 16											

Subject ID	Report Obj Secure	Establish Strongpoint	Proper SitRep	Link Up w/ Grd Force	Walk Thru/ Chng Over	Request Evacuate	Link Up w/ DM	Security Shooter	Evacuate Asslt Force
7139	-2	0	0	-1				-1	
4451	0	0	-1						
4789	0	0	0	-1		-1	-1		
8203	0	0	-1	-1	-1		-1	-2	
6833	-2	0	-1					-3	
4920	0	0	0						
9060	0	0	0				-1		
3692	-2	0	0					-3	
2007	-2	0	0					-3	
8476									
0161	0	0	-1						
8573	0	0	-1					-3	
5846	-3	-1	-1					-3	
2085	-2	-1	-1						
8927	0	0	-1					-3	
4179									
Control 1									
Control 2	-2	0	-1					-3	
Control 3									
Control 4	0	0	-1						
Control 5	0	0	0					-3	
Control 6	0	0	-1	-1					
Control 7	-2	0	0					-1	
Control 8	0	0	-1					-3	
Control 9	-1	0	-2					-3	-1
Control 10	0	0	-1					-3	
Control 11	0	0	-1						
Control 12	-2	-1	0	-1				-1	
Control 13									
Control 14									
Control 15									
Control 16									

Subject ID	**Negligent Discharge**	**Muzzling**	**Finger on Trigger**	**Door Chk at Index**	**Weapon on Fire**	**Failure to Decock**	**Failure 6' Rule**
7139						-10	
4451						-10	
4789							
8203							
6833							
4920			-15				
9060						-10	
3692							
2007					-5		
8476							
0161							
8573							
5846							
2085						-10	
8927							
4179							
Control 1							
Control 2						-10	
Control 3		F					
Control 4						-10	
Control 5							
Control 6							
Control 7							
Control 8							
Control 9							
Control 10							
Control 11							
Control 12					-5		
Control 13							
Control 14							
Control 15							
Control 16							

Subject ID	Tactical Score	Rank	Safety Violations	Total Score	Rank
7139	87	7.5	-10	77	10.5
4451	94	23	-10	84	18
4789	88	11		88	24.5
8203	82	1.5		82	14.5
6833	87	7.5		87	22
4920	92	20.5	-15	77	10.5
9060	93	22	-10	83	16
3692	88	11		88	24.5
2007	91	17.5	-5	86	20
8476			F X 2	0	4.5
0161	95	24		95	32
8573	87	7.5		87	22
5846	84	4.5		84	18
2085	88	11	-10	78	12
8927	89	14		89	27
4179			F X 2	0	4.5
	88.93	**13.04**		**74.06**	**17.53**
Control 1				84.642857	
Control 2	83	3	-10	73	9
Control 3			F	0	4.5
Control 4	91	17.5	-10	81	13
Control 5	87	7.5		87	22
Control 6	92	20.5		92	31
Control 7	91	17.5		91	29.5
Control 8	84	4.5		84	18
Control 9	89	14		89	27
Control 10	82	1.5		82	14.5
Control 11	91	17.5		91	29.5
Control 12	89	14	-5	89	27
Control 13			F X 2	0	4.5
Control 14			F X 2	0	4.5
Control 15			F X 2	0	4.5
Control 16			F X 2	0	4.5

LIST OF REFERENCES

Acton, CDR B. J., US Navy, 1998. Objective Based Training, A Requirements Approach. Paper presented at ITEC '98.

Acton, B. J., 2001. Objective Based Training and the Battle Force Tactical Training System; Focusing our Fleet Training Processes. Paper presented at I/ITSEC 2001.

Amory, et al. (1998). Computer Games as a Learning Resource. Durban, South Africa: University of Natal.

Appel, V. H., Grubb, P. D., Elder, E. D., Leamon, R. E., Watson, T. W., & Earles, J. A. (1991). *Leadership Effectiveness Assessment Profile (LEAP): Organizational taxonomy and enlisted item pool development* (AL*-TP-1991-0025). San Antonio, TX: Universal Energy Systems Inc. (DTIC Report No. AD-A239-973)

Barlow, M., et al. (2004). *Factors in Team Performance in a Virtual Squad Environment*. In SimTecT 2004 Conference Proceedings, Canberra, May 2004, 94-99.

Caillois, Roger (1958). *Les jeux et les homes*, Paris.

Cameron, J. A. & Urzi, D. A. (1999). *Taxonomies of Organizational Behaviors: A Synthesis* (CSERIAC-TR-99-002). Wright-Patrick AFB, OH: CSERIAC Program Office AFRL/HEC/CSERIAC. (DMSO Report)

Cannon-Bowers, J. A. and Salas, E. (eds) (1998). *Making Decisions Under Stress: Implications for Individual and Team Training.* Washington, DC: American Psychological Association.

Cannon-Bowers, J. A., Salas, E., & Converse, S. A. (1993). *Shared mental models in expert decisionmaking teams*. In N. J. Castellan, Jr. (Ed.), Current issues in individual and group decision making (pp. 221-246). Hillsdale, NJ: Erlbaum.

Carpenter, R. & White, C. (2005). Commercial Computer Games in the Australian Department of Defence

Commander, Naval Surface Forces Instruction 3502.1A, Surface Force Training Manual, 7 April 2003.

Commanding Officer, Marine Corps Security Force, Training Company letter 1500 CQB/JSD 22 Sep 05. Letter of Instruction for Close Quarters Battle Course 1-06.

Cosby, Neale & Severinghaus, Rick (2003). The M&S Void: Simulations for Individual and Small Teams (03E-SIW-103). European Simulation Interoperability Workshop.

Crawford, Chris (1984). *The Art of Computer Game Design*, Mcgraw-Hill Osborne Media

Cybernet Systems Corporation (2005). The OpenSkies Training Method. Available: http://www.openskies.net/training/features/method.html.

Defense Science Board (2001). 2001 Report of the Defense Science Board Task Force on Training Superiority & Training Surprise.

Department of the Navy (2000). The Battle for Hue: Casualty and Disease Rates During Urban Warfare.

Dwyer, D. J., Oser, R. L., Salas, E., & Fowlkes, J. E., 1999. Performance measurement in distributed environments: Initial results and implications for training. Military Psychology 1999, Vol. 11(2), 189-215.

Fiore, S. M., Cuevas, H. M., Scielzo, S., & Salas, E. (2002). Training individuals for distributed teams: problem solving assessment for distributed mission research. *Computers in Human Behavior,* 18, 729-744.

Fiore, S. M., Salas, E., Cuevas, H. M., & Bowers, C. A. (2003). Distributed coordination space: toward a theory of distributed team process and performance. *Theoretical Issues in Ergonomics Science*, July-December 2003, Vol. 4, Nos. 3-4, 340-364.

Fowlkes, J., Dwyer, D. J., Oser, R. L., & Salas, E., 1998. Event-Based Approach to Training (EBAT). The International Journal of Aviation Psychology, 8(3), 209-221.

Fowlkes, J. E., Lane, N. E., Salas, E., Franz, T., and Oser, R. (1994). Improving the measurement of team performance: The TARGETs methodology. Military Psychology, 6, 47-61.

Gonzales, F. E. & Cathcart, M., (1995). "A procedure for studying strategy development in humans," *Behavior Research Methods, Instruments, & Computers*, 27, 224-228, 1995.

Greenfield, Patricia M., (1984) *Mind and Media: The Effects of Television, Video Games and Computers*, Harvard.

Gundersen, M. (1997). Position Paper. Committee on Modeling and Simulation: Opportunities for Collaboration Between the Defenxe and Entertainment Research Communities. Washington, D.C.: National Academy Press.

Henegan, N. (2005). *Soldiers to Train on Computer Games.* Available: http://www.telegraph.co.uk/news/main.jhtml?xml=/news/2005/11/06/ngame06.xml&sSheet=/news/2005/11/06/ixhome.html.

Homan, W. J. (1998). Design of Multimedia Situational Awareness Training for Pilots. Educational Media International, 35 (1), 21-25.

Indik, B. P. (1968). The scope of the problem and some suggestions toward a solution. In B. P. Indik and F. K. Berrien (Eds.), *People, groups, and organizations* (pp. 3-26). New York: Teachers College Columbia University, Teachers College Press.

Ioerger, T.R. (2003). Literature Review: Modeling Teamwork as Part of Human Behavior Representation. Technical report TSSTI-TR-10-03, Training System Science and Technology Initiative, Texas A&M University.

Krulak, General Charles H. (1999, June). Interview with Jim Lehrer, Public Broadcasting System.

Laird, J. E. (2000, May). An Exploration into Computer Games and Computer Generated Forces. The Eighth Conference on Computer Generated Forces and Behavior Representation. Orlando, FL.

Laird, J. E. and van Lent, M.C. (1999). “Human-level AI’s killer application: Interactive computer games.” *American Association for Artificial Intelligence Spring Symposium Series: Artificial Intelligence and Interactive Entertainment*, Orlando Florida.

Lennox, LTG W. J., US Army, 2003. The Supe’s Letter. September/October 2003. Available: http://www.aog.usma.edu/PUBS/ASSEMBLY/030910/supe.htm [2003, October 8].

Marine Corps Security Force Battalion Training and Readiness Manual (Short Title: MCSF Bn T&R Manual), NAVMC Directive 3500.80 (25 Jul 2005).

Marine Corps Warfighting Laboratory (2001). Http://www.mcwl.quantico.usmc.mil.

McCarty, C. T. (2001). Playing with Computer Games: An Exploration of Computer Game Simulations and Learning. University of London Institute of Education.

Might, R. J. (1993, June). Principles for the Design and Selection of Combat Simulations. Simulation & Gaming, 24, 190-212.

Morrison, P. & Barlow, M. (2004). Child's Play? Coercing a COTS Game into a Military Experimentation Tool. *Proceedings of SimTecT 2004*, May 2004 (72-77). Canberra, Australia.

O'Neil, H. F., Jr., Chung, G., & Brown, R. (1997). Use of networked simulations as a context to measure team competencies. In H. F. O'Neil, Jr. (Ed.), *Workforce readiness: Competencies and assessment* (411-452). Mahwah, NJ: Erlbaum.

Oser, R. L., Cannon-Bowers, J. A., Dwyer, D. J., & Salas, E. (1997). Establishing a Learning Environment for JSIMS: Challenges and Considerations. Paper presented at I/ITSEC 1997.

Oswalt, I. (1993, June). Current Applications, Trends, and Organizations in U.S. Military Simulation and Gaming. Simulation & Gaming, 24, 153-189.

Oswalt, I. (1993, September). Military Simulations and Gaming Organizations. Simulation & Gaming, 24, 332-335.

Paris, C. R., Salas, E., and Cannon-Bowers, J. A. (2000). Teamwork in multi-person systems: a review and analysis. *Ergonomics*, Vol. 43, No. 8, 1052-1075.

Peters, V., Vissers, G., and Heijne, G. (1998, March). The Validity of Games. Simulation & Gaming, 29, 20-30.

Pillay, H., Brownlee, J., and Wilss, L. (1999). Cognition and Recreational Computer Games: Implications for Education Technology. Journal of Research on Computing in Education, 32(1), 203-215.

Porter, J. (1998). Understanding of Counting in Children with Severe Learning Difficulties and Nursery Children. British Journal of Educational Psychology, 68, 331-345.

Prensky, M. (2001). *Digital Game-Based Learning*, McGraw-Hill.

Proctor, M. D., Curley, J., and Williams, W. C. (2002) "Interoperable Training through a Simulation Game," *2002 European Simulation Interoperability Workshop*.

Proctor, M. D., Panko, M., and Donovan, S. (2004). "Considerations for Training Team Situation Awareness and Task Performance through PC-Gamer Simulated Multi-Ship Helicopter Operations," *International Journal of Aviation Psychology*, 14(2), 191 -205

Rantz, W. G. (1998). Effects of low fidelity computer software training on collegiate aviation student's affective and psychomotor skills. Kalamazoo, MI: Western Michigan University School of Aviation Sciences.

Salas, E., Oser, R. L., Cannon-Bowers, J. A., & Daskarolis, E., 1999. Team Training in Virtual Environments. In K. M. Stanney (Ed.), VE Handbook, University of Central Florida: Lawrence Erlbaum Associates, Inc.

Schwalbe, S. R. (1993, September). War Gaming: In Need of Context. Simulation & Gaming, 24, 314-320.

Sells, S. B. (1968). General theoretical problems related to organizational taxonomy: A model solution. In B. P. Indik and F. K. Berrien (Eds.), *People, groups, and organizations* (pp. 27-46). New York: Teachers College Press.

Starling, J. (2001, February). Academies use computer games as training aids. Marine Corps Times, 3 (4).

Tallal, P. et al. (1996). Language comprehension in language-learning impaired children improved with acoustically modified speech. Science, 271, 81-84.

Tarr, R. W., Morris, C. S., and Singer, M. J. (2002). Low Cost PC-Gaming and Simulation Research: Doctrinal Survey. United States Army Research Institute for the Behavioral and Social Sciences.

Thurman, R. A. and Dunlap, R. D. (2000). Assessing the effectiveness of simulator-based training. Proceedings of the 21st Inter-service/Industry Training, Simulation, and Education Conference, Orlando, Florida.

Thurman, R. A. and Mattoon, J. S. (1994, October). Virtual Reality: Toward Fundamental Improvements in Simulation-Based Training. Educational Technology, 56-64.

van Lent, M. C., et al. (1999), Intelligent Agents in Computer Games, American Association for Artificial Intelligence.

Woodall, D., 2002. Evaluating e-Learning Solutions: Choosing the right e-Learning solution for your organization. Available: http://www.skillsoft.com/solutions/files/Evaluating e-Learning whitepaper 9.13.02_revised.pdf [2003, October 13].

Wright, E. H. (1990). *Objective Base Training Theory Applied to Construction Firms in Transition to Robotics and Automation*, ASC Proceeding of the 26th Annual Conference, 181-186.

Yin, R. K. (2003). Case Study Research: Design and Methods (3rd Edition). Thousand Oaks, CA: Sage Publications, Inc.