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A COMPUTER-BASED SIMULATION TO ACCELERATE MILITARY DECISION-MAKING USING A PLATOON TACTICAL DECISION GAME (TDG)

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THESIS

A COMPUTER-BASED SIMULATION TO ACCELERATE MILITARY DECISION-MAKING USING A PLATOON TACTICAL DECISION GAME (TDG)

by

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June 2022

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The Marine Corps has long used tactical decision games (TDG) to train and evaluate leadership and decision-making abilities. The antiquated process of using pencil and paper or dry erase boards requires a subject-matter expert to be present to evaluate and assess each individual Marine's scheme of maneuver and provide immediate feedback of their maneuver plan. This process is time-consuming and does not allow Marines to conduct the reps and sets necessary to build their intuitive decision-making and gain experience in various situations. Regardless of the mission, the Marine Corps requires leaders to succeed in combat by being prepared to act as if, even when they're in a situation for the first time.

A computer-based TDG was designed to allow Marines the ability to gain experience in a platoon maneuver through successive repetitions in a time-constrained environment in unknown terrain with varying enemy situations. This system allows Marines to get the repetitions they need to build their decision-making skills and supplement instructor-led training. Using a repeated measures design, the data suggest that using a computer-based TDG shortens the decision-making cycle time for Marines and shows an increase in accuracy of selecting the correct maneuver path through rapid repetition.

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LIST OF ACRONYMS AND ABBREVIATIONS

AAR	after action review
ANOVA	analysis of variance
.csv	comma separated value file
CCM	Close Combat Marine
CDR	Combat Decision Range
CMC	Commandant of the Marine Corps
COA	course of action
CPG	Commandant’s Planning Guidance
DOD	Department of Defense
ETDG	Evaluative Tactical Decision Game
FM	Field Manual
H0	Null Hypothesis
HA	Alternate Hypothesis
HPT&E	Human Performance, Training and Education
IOC	Infantry Officer Course
IRB	Institutional Review Board
ITDG	Interactive Tactical Decision Game
MAGTF	Marine Air Ground Task Force
MCDP	Marine Corps Doctrinal Publication
MCSTE	Marine Corps Synthetic Training Environment
MOS	military occupational specialty
MOVES	Modeling, Virtual Environments, and Simulation
NPS	Naval Postgraduate School
ONR	Office of Naval Research
OODA	Observe-Orient-Decide-Act
PFDT	platoon formation decision task
PME	professional military education
PM TRASYS	Program Manager Training Systems
POI	program of instruction

RPD	Recognition-primed decision
S&T	Science and Technology
SOM	scheme of maneuver
STO	Science and Technology Objective
SUS	system usability scale
T&E	Training and Evaluation
T&R	Training and Readiness
TBS	The Basic School
TDG	tactical decision game
TDK	Tactical Decision Kit
TDS	tactical decision simulation
TTPs	tactics, techniques, and procedures
USMC	United States Marine Corps
VR	virtual reality

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I. INTRODUCTION

The United States Marine Corps does not currently have a system or method to assess platoon-level tactical decision-making through the use of a Tactical Decision Game (hereafter TDG). In formal schools and the Fleet Marine Force, a dry erase board is the medium used to conduct TDGs with feedback coming directly from an instructor. This process allows for only one Marine to be evaluated at a time and requires an instructor to evaluate each student individually. This process is lengthy and does not allow a Marine to conduct multiple repetitions in rapid succession. Furthermore, it has inherent problems with consistency across trainees and the feedback they receive. This thesis developed and evaluated a system capable of providing students with immediate feedback through a computer-based TDG.

A. BACKGROUND AND MOTIVATION

In 2017, the Marine Corps invested in the Tactical Decision Kit (TDK), a system utilizing an Interactive TDG (ITDG) system that "allows the users to create and execute in-depth, customizable TDGs that show second and third order effects of decisions, as well as being capable of preparing AARs, debriefs, or digital Sand Table Exercises, among other uses" (Marine Corps Rapid Capabilities Office, n.d.). In 2020, the Marine Corps announced the divestment of the TDK program in order to utilize the hardware and software for other simulated training capabilities. The ITDG was a computer-based system with the ability to assign student and instructor roles with multiple computers networked together through a server-client connection. When in this mode, instructors could develop scenarios on their computer and push it to the screens of students to develop their scheme of maneuver (SOM) and when the instructor pressed the "pens down" command, all screens were frozen. The TDK system also came with a projector to allow the instructor to then post students' work to the screen and wargame different solutions developed. The system lacked feedback to the student and still required an instructor to score and evaluate the SOMs presented. Not only did the instructor still need to evaluate every student's work, but they needed to develop the scenarios beforehand in order to accomplish the training goals. The 132-page user guide outlines all necessary instructions for server-client set-up, scenario development, student/instructor instructions, and troubleshooting errors. After being fielded for less than three years, infantry battalions found markers and dry erase boards more user friendly and efficient than the ITDG system, leading to unused equipment and eventually the divestment of the program.

This is not the first system the Marine Corps has developed and divested after only a few years of use. *Close Combat Marine* (*CCM*), a real-time computer-based strategy tactical decision-making simulation (TDS), was developed to teach tactics at the squad, platoon, and company levels. Similar to the ITDG, instructors were able to develop their own scenarios to mimic real life situations. With a plethora of actions and commands to choose from, this was a time-consuming game to learn in order to effectively train. Another system, the *Combat Decision Range* (*CDR*), was a PC-based, event-driven decision-making simulation where a Marine was provided with videos of a real-world situation and asked to make decisions based on what they have seen. Their decisions led to a series of events based on the course of action selected. This training simulation was best performed under the guidance of an instructor, who was able to guide the Marine's decisions and ask pointed questions to determine why courses of action were chosen among the rest. Table 1 displays a list of prior unsuccessful Marine Corps decision-making simulations and the reasons for their divestment.

Table 1. Prior Marine Corps decision-making simulations

Years in use	Simulation	Uses	Reason for divestment
1995-1997	*Marine Doom*	-Computer-based first-person shooter -Multiplayer to support fire team training	-Technology breakdowns and maintenance; system always under repair -Requires technicians to run the program
1999-?	*Combat Decision Range (CDR)*	-Individual decision-making scenario videos on a computer -Train individuals in rules of engagement decisions	-Requires technician to run the computer -One Marine at a time -Requires evaluator to assess decisions
2004-2007	*Close Combat Marine (CCM)*	-Computer-based third-person game -Command squad to company in historic battles (Normandy, Battle of the Bulge, etc.)	-User must assess their own success or failure -Large bank of TCMs and unit graphics; unrealistic assets available to squad leaders
2017-2019	*Tactical Decision Kit (TDK)*	-VBS3 capable for fire team to battalion co-play -Interactive TDG capability with real-world maps	-Requires gaming laptops to run software -Requires client-server connections -132+ page startup guide -Scenario builder too time consuming

In July 2019, the Commandant of the Marine Corps (CMC), General David H. Berger, published his planning guidance urging leaders to "focus on force design, warfighting, education and training, core values, and command and leadership" (Berger, 2019). The CMC further elevated the importance of simulated training when he stated, "Our training facilities and ranges are antiquated, and the force lacks the necessary modern simulators to sustain training readiness" (Berger, 2019, p.6). As the CMC identified, the Marine Corps lacks modern simulation systems in order to effectively train and evaluate our forces. The Marine Corps has begun a shift in warfighting and doctrine and as part of this shift we have seen a downsizing of the force in order to shift capabilities for the next fight. Most of our current training and evaluation systems revolve around urban combat, stability, and counter insurgency operations, which encompassed the majority of the fighting in Iraq and Afghanistan over the past two decades. As we prepare for the next conflict, simulated training is a valuable way to prepare our Marines for tactics, techniques, and procedures (TTPs) used by our next adversary by allowing leaders rapid repetitions in succession to build their analytical and intuitive decision making. Simulated training environments will allow us to meet the Commandant's guidance in modernizing the Corps in a fiscally responsible way and using simulated training to improve and sustain readiness.

The Program Manager Training Systems (PM TRASYS) is a part of Marine Corps Systems Command that is charged with providing the Marine Corps training support and developing and maintaining various training systems. Some of the training products supported by PM TRASYS include "simulators, mock weapons, range targets, range instrumentation, training technology research and development, distributed learning capabilities, training observation capabilities, and after-action review systems" (United States Marine Corps, 2019). TDS technology has been one of the four major areas of applied research and development for PM TRASYS Science and Technology (S&T) Division since the inception of *Marine Doom* from 1995 to 1997. *Marine Doom* was an adaptation of the game *Doom II,* a first-person shooter computer game created by id Software as a multiplayer game to play cooperatively. The Marine Corps Modeling and Simulation Management Office (MCMSMO) adapted the game for training four-man fire teams. The game was designed to teach tactical concepts like maneuver warfare, mutual support, sequence of actions on an objective, and command and control. The computer game incorporated M16A1 rifles, M249 light machine guns, and M67 fragmentary grenades (Program Manager Training Systems Science and Technology [PM TRASYS S&T] Division, 2004).

Marine Doom was ultimately the precursor to a later program of record, the Deployable Virtual Training Environment (DVTE), a simulation designed to present students with a tactical situation for which they can develop a plan to execute fires missions in support of the specified tactical scenario. The simulation is modeled to simulate the execution of combined arms in support of company or battalion operation. As stated in an article written by the PM TRASYS S&T Staff, "Repeated simulation play will enhance their skills as commanders and planners" (PM TRASYS S&T Division, 2004). This system has been deployed at Marine Corps installations around the world and is still in use today for fire support team (FiST) and joint terminal attack controller (JTAC) training.

As this section described, the Marine Corps has invested in many computer-based decision-making simulations for ground troops since the mid-90s, yet none are still in use today. The Department of Defense (DOD) has long used simulators for piloting of aircraft, driving ships, and driving combat vehicles, but have yet to successfully field a decision-making simulation for ground troops.

B. RESEARCH QUESTIONS

- Research Question 1: To what extent can the cycle time from data-gathering to decision-making be shortened via training of platoon decisions on a computer-based simulation?

- HA1: Effective training will be demonstrated by participants, on average, selecting acceptable decisions (score of 70%) in the allotted time for each scenario presented, $\mu > .70$.

- HA2: Participants experience a decrease in average time to complete TDGs throughout the training iterations, $\Delta\mu\text{time} < 0$.

- Research Question 2: To what extent is a computer-based tactical decision game (TDG) a usable training device for tactical decision making?

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II. LITERATURE REVIEW

The literature review is organized into three sections. The first section discusses the emphasis the military places on decision-making and how this and leadership potential has been evaluated throughout history. This section will also discuss the utilization of tactical decision games and tactical decision simulations in the evaluation of leadership and decision-making abilities. The second section will introduce the recognition primed decision (RPD) model, which aims to study how people make real-world decisions in high stress high stakes environments. The final sections discuss the pinnacle of Marine Corps tactics and the tenants of winning in combat through maneuver warfare.

A. MILITARY DECISION-MAKING AND LEADERSHIP IN TRAINING

The military places great emphasis on leadership for officers at all levels. At the Basic School (TBS) in Quantico, Virginia, Marine Corps lieutenants are taught the basic concepts of infantry combat and assessed in leadership and decision making. The Basic School's mission is to, "Train and educate newly commissioned or appointed officers in the lofty standards of professional knowledge, esprit-de-corps, and leadership required to prepare them for duty as company grade officers in the operating forces, with particular emphasis on the duties, responsibilities, and warfighting skills required of a rifle platoon commander" (United States Marine Corps, n.d.). In order for military officers to effectively lead, they must be capable of making timely and concise decisions in time constrained, uncertain situations.

Retired Army Lieutenant General Walter F. Ulmer Jr. stated in an article from *Armor Magazine*, that "leadership is not best assessed by traits and characteristics, but by the specifics of what leaders do" (Ulmer, 2006, p. 39). Based on historical studies of leaders that were widely regarded as "good," General Ulmer compiled a list of behaviors for leaders at all levels. This list was refined by a group of professors and students at the Army War College which ultimately became the Leader Behavior Preferences (LBP) Worksheet, as Figure 1 presents. This list has been further refined into subsets now called the "Big 12" as Figure 2 illustrates.

Leader Behavior Preferences (LBP) Worksheet

(Behaviors that create a command climate that supports operational excellence and motivates competent people to continue military service.)

Specific leader behavior (for a division commander)				
1. Adapts quickly to new situations and requirements.				
2. Understands and employs current Army and Joint doctrine.				
3. Keeps cool under pressure.				
4. Knows how and when to involve others in decisionmaking.				
5. Clearly explains missions, standards, and priorities.				
6. Sees the big picture; provides context and perspective.				
7. Sets high standards without a "zero defects" mentality.				
8. Encourages initiative and welcomes new ideas.				
9. Backs up subordinates; confronts the boss if necessary.				
10. Is trustworthy; keeps promises or explains why he can't.				
11. Employs units in accordance with their capabilities.				
12. Can handle "bad news."				
13. Gets out of the headquarters and visits the troops.				
14. Coaches and gives useful feedback to subordinates.				
15. Sets a high ethical tone; demands honest reporting.				
16. Will share the risks and hardships of his soldiers.				
17. Knows how to delegate and not "micromanage."				
18. Is consistent and predictable in his behavior.				
19. Shows respect and consideration for others of any rank.				
20. Puts mission and people ahead of his own career.				
21. Is approachable; listens to questions and suggestions.				
22. Can make tough, sound decisions on time.				
23. Shares the limelight; gives due credit to others.				
24. Senses unproductive policies and makes prompt adjustments.				
25. Builds and supports teamwork within staff and among units.				
26. Holds people accountable for their actions and results.				
27. Is more interested in doing good than looking good.				
28. Is fair; doesn't play favorites with units or people.				
29. Is positive, encouraging, and realistically optimistic.				
30. Write in:				

Figure 1.

Note: This list may be reproduced with credit to AWC Study "Leadership Lessons at Division Command Level–2004."

Figure 1. Leader Behavior Preferences (LBP) Worksheet.
Source: Ulmer (2006).

"BIG 12"

At the top of the list: (In order of question number)

3. Keeps cool under pressure.
5. Clearly explains missions, standards, and priorities.
6. Sees the big picture; provides context and perspective.
22. Can make tough, sound decisions on time.

Also particularly significant: (In order of question number)

1. Adapts quickly to new situations and requirements.
7. Sets high standards without a "zero defects" mentality.
12. Can handle "bad news."
14. Coaches and gives useful feedback to subordinates.
15. Sets a high ethical tone; demands honest reporting.
17. Knows how to delegate and not "micromanage."
25. Builds and supports teamwork within staff and among units.
29. Is positive, encouraging, and realistically optimistic.

Figure 2

Figure 2. The "Big 12."
Source: Ulmer (2006).

By using this as a guideline, General Ulmer believed this was the first step towards better evaluation of our military leaders and many branches and schoolhouses today have evolved this list to be used for their specific training evaluations.

1. Decision Making

Throughout history, the United States military has placed great emphasis on leaders decision-making in order to implement their tactics and strategies in combat. The U.S. Army Field Manual *(FM) 100–5 Operations* defines decision-making as a "combination of information coupled with use of judgment as an element of combat power" (Department of the Army, 1993). The Marine Corps' TBS teaches that decision-making is a continuous cycle of analysis and intuition. Analysis being the slow, timely process of careful calculation, interpretation, and prediction. Intuition on the other hand is informed by past experience in order to make decisions faster, easier, and less taxing. Both types of decision-making used together inform and strengthen one another simultaneously and allow us to see each unique situation as that. As Marine Corps Doctrinal Publication (MCDP) 1 Warfighting (1997a) states, time is always a critical factor in the decision-making process and at times, the most important.

Carl von Clausewitz, a renowned Prussian general and military theorist, asserts that a tactical leader is generally required to make faster decisions than strategic-level leaders (Souchon, 2020). This is due to the immediate effects at the tactical level, equating to urgent life and death situations. Because of this, it is imperative that tactical-level leaders practice their decision-making in an environment where one must make decisions and see the consequences of those decisions. With today's technology, we have the ability to create that environment for leaders through the use of tactical decision-making games in a simulated environment.

The Marine Corps typically classifies tactical small unit level as platoon level and down, where immediate decisions are necessary for life and death situations. These decisions are generally made by lieutenants, at the officer level, and sergeants to staff sergeants on the enlisted side. In this range group, the average age of leaders is between 23 and 28 years old, far too young to be considered "experienced" in many occupational fields.

Leaders at the tactical level are forced to make split-second decisions, judging the situation based on information readily available and previous experiences. Many young Marines do not yet have the experiences needed to rely solely on that for judgement, therefore the military aims to place junior leaders in training throughout their professional military education (PME) to obtain routine tactical decision-making skills. Historically, this has been done through field exercises, situational training exercises, tactical vignettes, and leadership reaction courses. As of March 2001, the Army FM 7-8 has refined its definition of skills required by as leader by stating:

> Infantry platoon and squad leaders must be tacticians. They cannot rely on a book to solve tactical problems. They must understand and use initiative in accomplishing the mission. This means that they must know how to analyze the situation quickly and make decisions rapidly in light of the commander's intent. (Hanley, 2018)

When a platoon commander makes contact with the enemy, it is his responsibility to determine the best course of action (COA) within minutes. The platoon commander must assess the situation, decide on a COA, and act before the enemy has time to adjust their plan. One technique taught at the Basic School is Colonel John Boyd's "OODA Loop." Figure 3 depicts how the cycle works: observe, orient, decide, act.

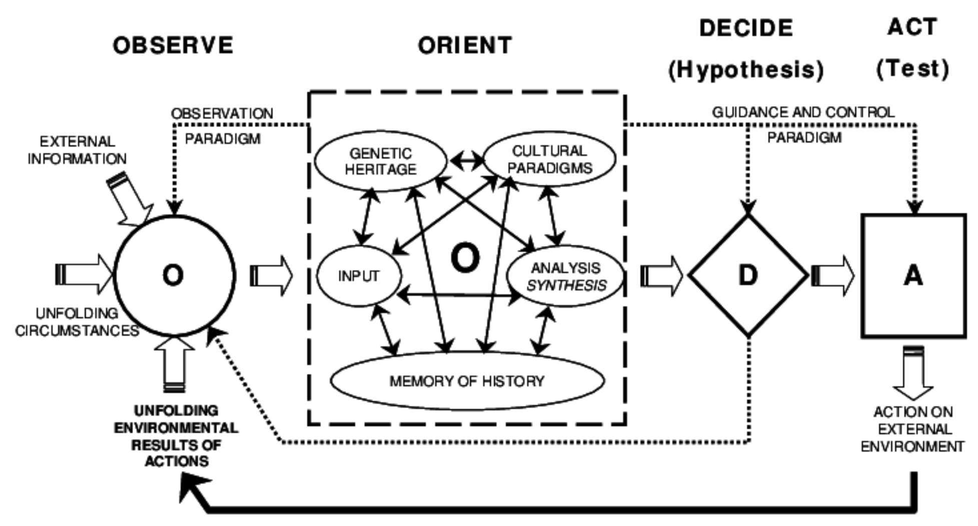


Figure 3. OODA Loop. Source: Ullman (2007).

The Observe-Orient-Decide-Act (OODA) Loop depicts naturalistic decision-making and can be applied for myriad experiences where a decision needs to be made. Marines are taught that one must first take in all information pertaining to the situation they are in (observe), filter through all inputs and determine the information most pertinent (orient), come to a decision on what must be done (decide), and lastly, execute that decision with violence of action (act). This is a continuous cycle that persists throughout operations and as Marines become more proficient in decision-making and gain experience, they are able to shorten the cycle time and outpace the enemy. This means an individual is able to mentally run through the OODA Loop faster than their adversary and win (Ullman, 2007).

2. Tactical Decision Games and Simulations

TDGs are defined by a 1989 Marine Corps handbook by saying,

> The tactical decision games (TDGs) are situational-based scenarios where individuals are required to exercise mental agility to meet the demands of the situational stimuli while implementing a problem-solving solution. The TDG can range from paper media to a situation given orally to Marines by a seminar leader or facilitator. (Marine Corps Institute, 1989)

Tactical decision games (TDGs) have their earliest roots back to Sun Tzu, a Chinese general and military theorist, from more than 2,500 years ago. Historical evidence has shown that the Chinese used TDGs as a way of teaching young leaders how to think and train as well as reinforce instituted ways operating (Vandergriff, 2006). The most heavily documented military to use TDGs to train and evaluate their soldiers was the Prussian Army throughout the mid-1800s. Army cadets were required to solve tactical problems with many unknowns and variables, and then verbalize their solution to their class and instructors. The goal of these tactical games was for instructors to find out how cadets would react when presented with a complex problem. Back then, the main concern was not whether or not decisions were made correctly but that a decision was made, period. As TDGs became more of an accepted training practice, the Marine Corps Institute (1989) developed a list of benefits and limitations:

Some benefits of TDGs include:

- Improving pattern recognition skills,
- Exercising the decision-making process,

- Improving and practicing communication skills,
- Increasing leadership potential.

Some limitations of the TDG are:

- Representing a snapshot in time,
- Allowing participants to make only one move,
- Simulating operating environment is difficult - impossible to simulate the friction and uncertainty of the operating environment,
- Working for units no larger than company level,
- Applying to special operations is difficult (Marine Corps Institute, 1989).

After adding TDGs into the curriculum at their district academies, where cadets were trained, military leaders began to see that cadets wanted to know more, asked more questions, and sought answers to tactical problems they did not know. The Prussian Army saw their cadets regularly conducting self-study on tactics and encouraged new and innovative discussions on ground forces employment. As TDGs became much more widely used and heavier weight was placed on them, they became an integral part of cadets' evaluations. Leaders used TDGs to assess cadets on their leadership and decision-making potential. As described by Vandergriff (2006):

> Weak performance on graded TDGs was grounds for failure on an exam or for expulsion from the academy. Signs of weak character were grounds for failing an exam, or worse, for a repeat offender, for expulsion from the course. The inability to make a decision or defend one's decision in the face of adversity was grounds for not being commissioned.

And beyond all, if a cadet failed to make a decision that was seen as an immediate failure. Vandergriff went on to explain that decision-making skills will continue to play a key role in shaping the skills of cadets for future generations. Today, TDGs are a regular part of many reserve officer training corps (ROTC) program of instruction (POI) and used as a tactical exercise without troops (TEWT). Field training is costly, in finances and time, and for an ROTC unit creating a tactical scenario on pen and paper is a quick and inexpensive way to immerse students in a combat situation. The most difficult aspect of TDGs today is ensuring a highly qualified and competent instructor. The instructor must be able to function as a referee/adjudicator as well as provide immediate and insightful feedback to students. If an instructor is providing inaccurate tactical guidance to students, then this negative training is doing more harm than good.

Acquiring good decision-making skills is an especially important quality for all military leaders at all levels, yet there may be few opportunities in the real-world to develop this skill. Due to this, military organizations have begun to recognize the utility of computer-based decision-making tools and their importance in the training of their leaders. The best decision-making environment is one that closely resembles one that would be seen in combat. Even live training events are difficult to simulate this environment due to fiscal, environmental, and safety constraints, and when trying to conduct many repetitions with a large audience require ample time. These decision-making environments also need to be conducted regularly in a Marine's training schedule, placing a decision-maker at critical decision points frequently in order to build their experience base and confidence level. decision-making

B. EFFECTIVENESS OF TDGS AND TDSS FOR TRAINING

There have been many studies evaluating the effectiveness of TDGs and TDSs as military leadership and decision-making tools. One such report, *Tactical Decision-making Simulations II*, was made for NAVAIR Orlando in 2004 and evaluated a TDS named Marine Air Ground Task Force XXI (MAGTF XXI). MAGTF XXI was developed as a decision-making simulation for MAGTF planners and operational and strategic level staff. The researchers were focused on investigating the effects of situational awareness on decision-making in a simulation and hypothesized that situational awareness would be higher in a TDG than in a TDS. This hypothesis was confirmed by their findings but noted that further research and studies should be conducted for the best ways to improve TDSs to increase situational awareness and have a more positive impact on decision-making training.

In a 2021 Naval Postgraduate School (NPS) thesis by Major Shane Robinette, he utilized Lieutenant Colonel Brian Hanley's, USA, computer-based platoon formation decision task (PFDT) system to assess the optimal decision-making for junior leaders'. The PFDT consisted of 32 scenarios randomly shown to users four times with a 10-second first-person view. Each scenario presented the user with a terrain video, assessment of the enemy situation, and a direction of attack from the enemy (see Figure 4).

Figure 4. User interface from PFDT. Source: Robinette (2021).

The user was then asked to select which of the three given platoon formations would be the most optimal given the situation. Major Robinette (2021) applied the PFDT data to the Cognitive Alignment with Performance Targeted Training Intervention Model (CAPTTIM) to gain an understanding of when and why "participants reached optimal decision-making" and why some pursued "suboptimal decisions" (Hanley, 2018). Major Robinette hypothesized that a decision-making training simulation could show an improvement in response time and success rate over the course of multiple iterations using the PFDT in two mediums: virtual reality (VR) and handheld tablet. His research suggests that utilizing multiple domains to train Marines in a platoon formation task will improve their response time and accuracy through rapid repetition, allowing us to train leaders to become familiar with unknown terrain and situations in simulation prior to being exposed to them in real-life combat.

In Ayvaz and Fitzpatrick's NPS master's thesis they conducted an experiment to determine the effectiveness of evaluating participants using TDGs and TDSs. The military culture has a tough time adopting TDSs because of the resemblance of a video game; we should be training not playing video games. Therefore, this thesis aimed to determine if TDGs and TDSs could both be used for effective training and evaluation in three aspects: leadership, decision making, and situational awareness. These aspects were evaluated in two ways: self-reported and evaluator reported. Subjects were split into two groups, one that conducted five pencil and paper TDGs and one that conducted five TDSs using *CCM* and reported how they believed their type of training evaluated each of the three aspects. All of the corresponding null hypotheses were that there is no difference in the evaluation of each aspect between TDGs and TDSs. From the data collected, the authors suggest that there is no significant difference in the evaluation of leadership between TDGs and TDSs, suggesting that both could be used as an "opportunity to exercise and evaluate leadership" (Ayvaz & Fitzpatrick, 2007). For decision making, the authors again accept the null hypothesis stating that the data suggests that there is no difference between TDGs and TDSs in evaluating decision making. The authors did not have accurate data for situational awareness; therefore, it was left as inconclusive (Ayvaz & Fitzpatrick, 2007).

The research described above is particularly important when it comes to training and evaluation of Marine leaders because it provides data suggesting that expensive and complex systems are not necessarily a better way to train and evaluate leadership and decision making. Rather, with advancements in technology, there is an opportunity to begin to automate and digitize TDGs in a way that can provide valuable feedback to Marines as well as be accessible anywhere utilizing off the shelf hardware.

C. RECOGNITION PRIMED DECISION MODEL

Recognition Primed Decision (RPD) model is a theoretical development in the field of naturalistic decision-making explaining how people make real-world decisions. This research first began with psychologist Dr. Gary Klein in 1993, where he interviewed 26 firefighters with an average of 23 years of experience in order to determine how they make decisions in high-stress, high-stakes environments (Klein, 1993). At the time, researchers believed that effective decisions depended on one generating a number of options and then comparing said options in an evaluative manner to select the best course of action. But, in situations with mere seconds to decide and act, there is no time to evaluate multiple actions. The RPD model thus showed that experienced decision makers could make acceptable decisions with minimal time available. When using the RPD model, subjects recognize patterns and cues from past experiences to rapidly make decisions in time pressured situation with imperfect information. One significant point of RPD model is the "assertion that people can use experience to generate a plausible option as the first one they consider." (Klein, 1993). Figure 5 depicts the RPD Model and the mental process a subject is going through.

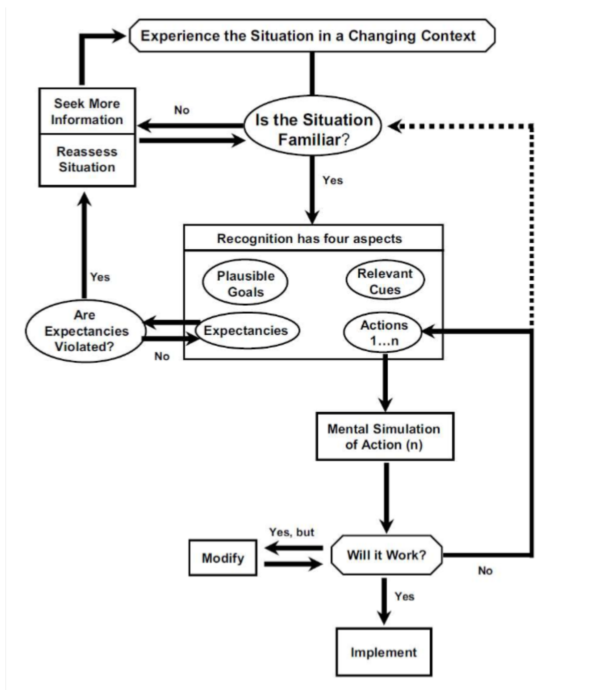


Figure 5. RPD Model. Source: Klein (1993).

In later work done with another psychologist, Dr. Daniel Kahneman, they broke up the way humans made decisions by coining the terms System 1 and System 2 thinking. System 1 describes the "fast, non-conscious, intuitive pattern-matching" and System 2 is the slow and deliberate decision making, also called analytical decision-making (Klein, 2021).

Military decision makers rely on RPD for operational planning in a time sensitive environment due to its speed and success in satisficing. As noted by Herbert Simon, Nobel Prize winner in economics, the idea of satisficing is "a cognitive heuristic that involves someone choosing to adopt the first acceptable option they come across" (Boella et al., 2011; Robinette, 2021). In order to build a leader's ability to use RPD, they must gain experience through repetition. Consistent with this idea, at The Basic School Marine Officers are taught that intuitive-decision-making needs to be built through deliberate practice and is not naturally occurring for most. By being able to repeatedly expose leaders to problems in a simulated environment, we allow them to increase their rapid decision-making based on cues from past experience and gradually build their ability to make intuitive decisions. This thesis utilized the RPD model to build Marine's intuition through repetition in decision-making tasks. Based on Klein's research, pattern recognition from previous experiences and repetitions allows leaders to evaluate choices quicker and use mental cues to make faster decisions in a time-constrained environment. Developing a system with a diverse repository of tactical scenarios could allow the military a solution to creating a diverse experience base and building intuition in leaders at all levels.

D. MCDP 1-3 TACTICS

MCDP 1-3 Tactics is a doctrinal publication of the United States Marine Corps that provides the basic tenants that the Marine Corps requires as necessary to winning in combat. As stated in MCDP 1-3, "Winning requires many things: excellence in techniques, an appreciation of the enemy, exemplary leadership, battlefield judgment, and focused combat power" (United States Marine Corps, 1997b). The publication goes one step further to say that winning and losing armies may contain the qualities above, but what sets them apart is that winning in combat relies on leaders ability to think and act in a decisive manner. This is the essence of tactical decision making. In order for the Marine Corps to win in combat, we must have tactical leaders that make sound decisions and judgement and to build that skill they must learn through study and practice. Tactics, as defined here, is broken down into two pieces: art and science. The art of tactics is how we, as leaders, creatively apply our military forces during a given situation. This can be applying our combat power in a way that is uniquely effective to the situation we are presented with.

The science of tactics involves mastering the techniques and procedures of warfighting. This includes skills in marksmanship, land navigation, crew-served weapons employment, and close air support. These skills require lots of study and repetition and "without mastery of basic warfighting skills, artistry and creativity in their application are impossible" (United States Marine Corps, 1997b). We must first teach and instruct our leaders in the science of tactics before they can begin to apply the art to unique environments. This is why repetition is so vital. When we allow Marines the ability to continually hone their tactical skills, we can effectively attempt to shorten their time from data collection to decision making.

1. Maneuver Warfare

In past military campaigns, leaders sought incremental gains in order to achieve victory in combat. This meant moving the forward line a few kilometers or taking a hill. Many of these victories could be written off as incompetence of the enemy or just luck based on the chaotic nature of war. This incremental form of warfare is best seen in the Western Front of World War I, where attrition warfare was the tactic of the time; raise the body count of the enemy. This is a slow, cumulative process that requires an immense number of resources and, quite frankly, wastes combat power. After the U.S. involvement in Vietnam, the Marine Corps began to embrace a more flexible and effective way to wage war which became known as maneuver warfare. Maneuver warfare aims at decisive action at critical points of combat versus the old tactics based on pure incremental attrition over time. Maneuver warfare embraces the use of speed and surprise to gain an advantage over the enemy and continually assess how to exploit enemy strengths or weaknesses. Since every situation is different, a commander must continually ask himself, "In this situation, what efforts will be decisive?" (United States Marine Corps, 1997b). This requires the commander to continually consider the factors of mission, enemy, terrain/weather, troops/fire support, time available, and civilian considerations, commonly referred to as a METT-TC analysis. The commander must be making assumptions about the enemy and determine what actions must be taken to achieve a result.

2. Achieving a Decision

For every situation, a leader must sift through confusing and incomplete pieces of information to determine what is useful and important in making a decision. Most importantly, the commander must determine what the enemy is attempting to do and counter that action. As MCDP 1-3 points out, one of the essential skills for a leader is the ability to recognize patterns. This publication defines pattern recognition as "the ability, after seeing only a few pieces of the puzzle, to fill in the rest of the picture correctly. Pattern recognition is the ability to understand the true significance and dynamics of a situation with limited information. Pattern recognition is a key skill for success on the battlefield." (United States Marine Corps, 1997b). A leader must be able to quickly recognize pertinent information to that situation and use it in a way that allows him to reach a decisive action. In a perfect world, commanders will have time to analyze situations and conduct deliberate planning, considering multiple courses of action and determining the best one. This is commonly known as analytical decision making. But in the heat of battle, when time is limited and decisions must be made quickly, leaders need to leverage a different type of decision-making commonly called intuitive decision making. "Intuitive decision-making relies on a commander's intuitive ability to recognize the key elements of a particular problem and arrive at the proper decision without having to compare multiple options" (United States Marine Corps, 1997b). As the publication continues to describe, intuition is a skill leaders develop over time through self-study and practice. Leaders with strong situational awareness and a broad experience base can quickly act based on their intuitive understanding of a given situation. They can reach back to prior experiences and quickly determine what needs to be done. This very quick insight is often referred to as *coup d'oeil* (KOO-DWEE), which is a French term meaning "stroke of the eye." Others have also referred to this quick reaction as a "tactical sense." In order to build our leaders intuition, we must subject them to a myriad of problems or scenarios in training to give them experiences to "reach back to" in order to shorten their decision-making time (United States Marine Corps, 1997b).

3. Being Faster

In order to gain and maintain momentum over our adversaries, we must be faster than them. We are not only talking about being physically faster, but mentally faster in decision making. In order to be superior consistently, we must continue to use our relative speed over time. This means not just moving faster than our enemies in one instance but continuing to maintain speed for the duration of combat operations. We realize that it is unrealistic to operate at full speed indefinitely, which is why we must maintain *relative speed* over the enemy. This simply means we must be outpacing the enemy relative to their speed. One way we achieve this is through combined arms, keeping constant pressure on the adversary as we maneuver, resupply, or recover. We leverage certain assets to allow others to rest or re-engage. Maneuver also cannot be sustained indefinitely, but we can maintain a certain momentum through meticulous planning of combined arms, ensuring the enemy is always at a disadvantage. We can allow the enemy's speed to a near halt; therefore our relative speed is always exceeding that of the enemy. This constant momentum is how our forces remain faster than our adversary.

III. METHODOLOGY

This chapter explains the steps taken in the system design and development as well as the experimental design of this study. We will begin by discussing the target population for this study, their selection criteria, and justification for why this population was chosen to sample from. The second section will explain the development of the Evaluative Tactical Decision Game (ETDG). The third section discusses the procedures employed for the experimentation. This study has been reviewed and approved by NPS and USMC Human Research Protection Program Institutional Review Boards (IRBs).

A. PARTICIPANTS

For this study, the target population were recently graduated students from TBS; basic trained Marine Corps officers with introductory knowledge on infantry tactical training, including platoon-level tactics. Furthermore, the specific group we aimed to select from were students awaiting follow-on training and the Infantry Officer Course (IOC), the required training for officers to receive the designator 0302 Infantry Officer. In 2018, Lieutenant Colonel Brian Hanley, USA, conducted his research with the PFDT using a group of non-infantry trained personnel, judging their knowledge and proficiency in platoon combat formations. This study differs in that we are focused on students with basic infantry tactics training but who have not yet completed their follow-on MOS certification training. Since repetitions are a way to build one's intuitive decision making, students at TBS could utilize the ETDG to sharpen their tactical decision-making abilities and build a foundation of basic rifle platoon tactics, while receiving valuable feedback to correct errors. Furthermore, the ETDG could also be leveraged to continue to sustain their knowledge while awaiting follow-on training and present themselves with more difficult, varying situations. All participants for this study were volunteers and received no incentives or compensation for participating in this study.

B. DESIGN

The goals of the ETDG were to design a computer-based system that could provide Marines with a situation, mission, and map graphic in the form of a TDG. Then, ask them to conduct quick critical thinking to develop a maneuver plan and receive immediate feedback on that plan based on tactical cues given and the enemy and friendly situation at hand.

The primary objective was to develop a system that was capable of providing students with a computer-based TDG with a simple system of scoring a maneuver plan, given a map, situation, and enemy and friendly graphics. In order to accomplish this objective, a student would require a way of "drawing" their route on the map and differentiate between maneuver and support units. The student would also need to be able to make changes to their plan and submit a final plan once they are ready. The students must also have access to written information in the form of a quick situation update to an existing operations order to guide their decision making. For the feedback portion, there must be some process in place to assign a score to a student based on tactical mobility corridors used, cover and concealment, and a prescribed direction of attack. As the objective became clear and the tasks to accomplish the tasks were highlighted, a basic requirements document was drafted and presented to the NPS FutureTech team to begin working on a prototype.

1. Task Analysis

After determining the objectives of the system, a basic tasks analysis was conducted to outline for the design team what general tasks the user needed to accomplish in sequence. These tasks are the generally accepted standard for conducting a TDG in the Marine Corps as described in Schmitt & *Marine Corps Gazette* (2002):

1. Student receives operations order or enemy situation
2. Student draws route for maneuver and support by fire elements on a map with gridlines
3. Student submits maneuver plan or time runs out
4. Student receives feedback in the form of a map overlay and written or verbal explanation

This task analysis describes the general sequence of events within a TDG. Generally, in a seminar style TDG, there would be a fifth sequence consisting of discussion amongst the students and instructor and then the sequence repeats with a new student.

2. System Requirements

After initial planning and development meetings with the NPS FutureTech team, we began developing an initial list of system requirements to begin initial drafting of the system. At this early stage in the process, there were only nine firm requirements that the system must be capable of, as determined by the student researcher. They were:

1. System shall have a text box with enemy situation that can be opened and closed by the user
2. System shall have a map loaded onto the screen depicting enemy graphics over terrain with gridlines
3. System shall present the user with three squad unit graphics to be dragged and dropped
4. System shall allow user to select friendly graphic and then draw a single line from the graphic to the enemy. (Google Maps style, left click to highlight graphic, right click continuously to draw line, press button to finish drawing line)
5. System shall allow the user to select drawn lines and delete in order to re-do
6. System shall be capable of assigning point values based on the scheme of maneuver of the user.
7. System shall give the user immediate feedback on their answer upon the end of the scenario. This shall be in the form of a map overlay and description.
8. System shall be capable of keeping track of time (when scenario begins to when it ends)

9. System shall be capable of terminating scenario after a given amount of time.

These requirements were presented to the FutureTech team along with a rough draft of what the map was intended to look like and how the user would be expected to draw their routes (see Figure 6).

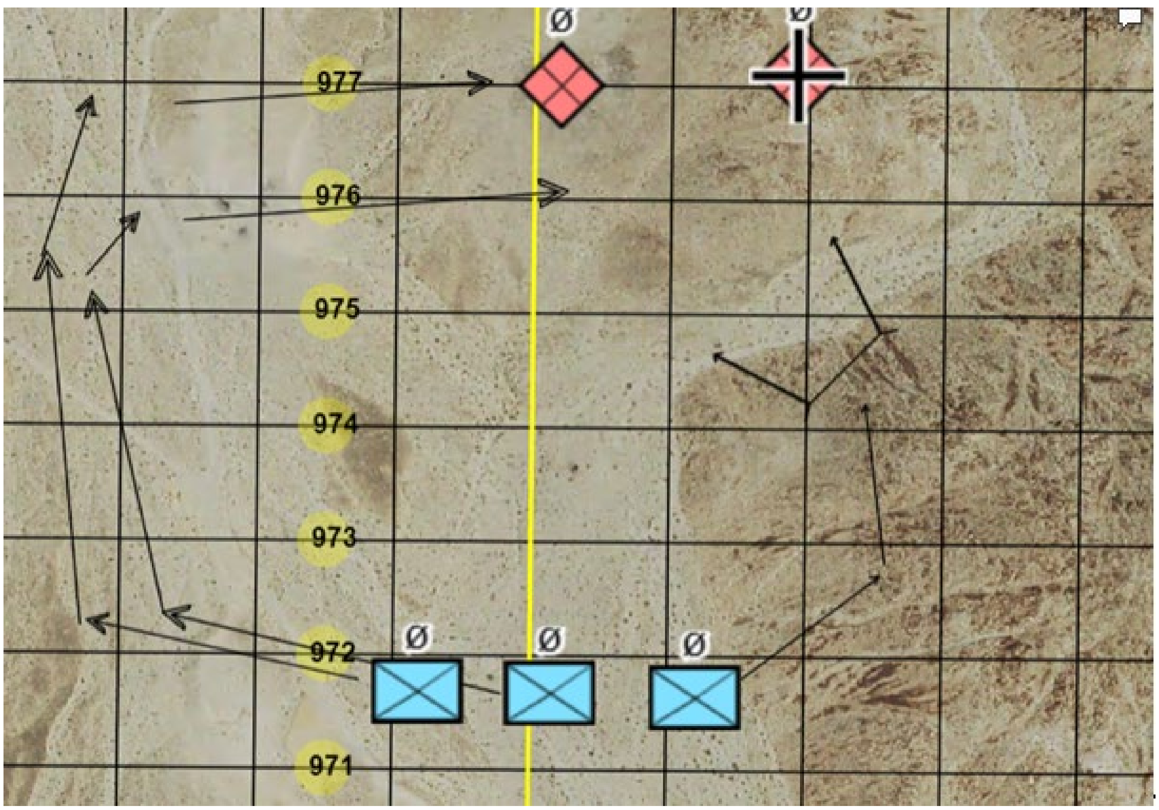


Figure 6. Initial Concept for ETDG

3. Scenario Development

After discussing the system requirements and ensuring all were feasible and understood, the team began developing the foundation for the system. At this point it was time to begin developing the tactical scenarios. The terrain was all generated based on screenshots from Google Maps along with latitude/longitude grid locations and orientation to allow the design team to import the maps using a terrain import tool in Unity3D. Using Microsoft PowerPoint, screenshots were placed on a blank slide and used the shapes function to draw and color friendly and enemy squad graphics to depict the starting point of a friendly unit and enemy position on the map. A brief description of the enemy situation was given to be added as a text box in the system. See Figure 7 for the initial scenario development provided to the FutureTech team.

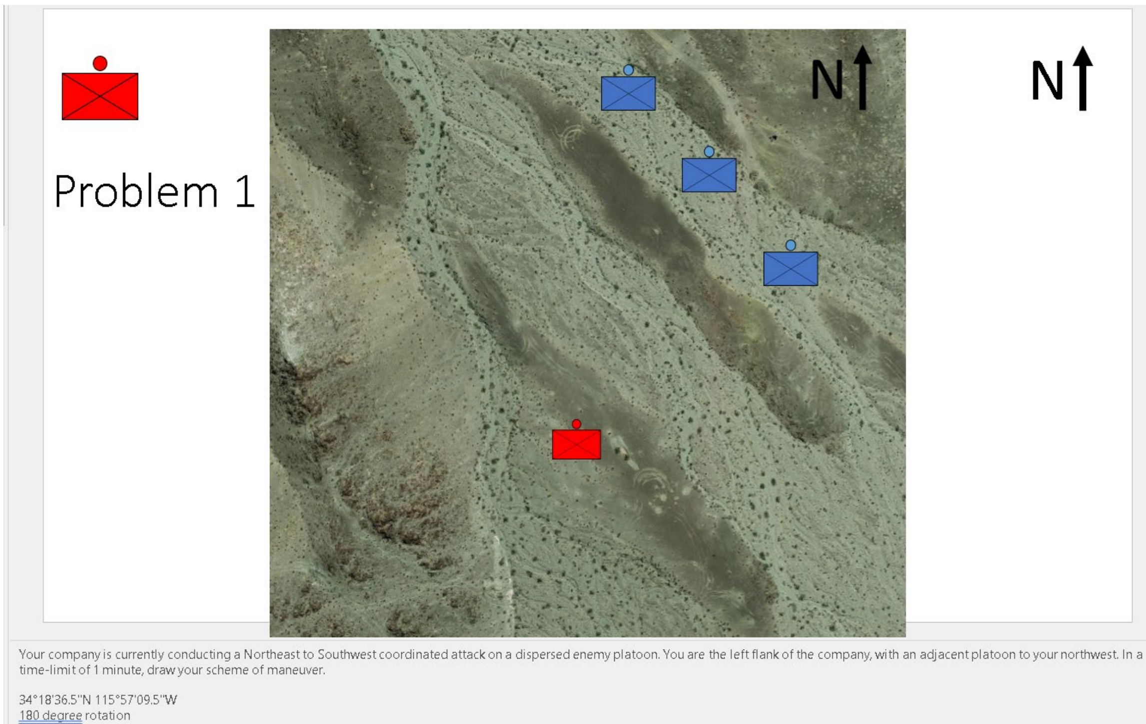


Figure 7. Initial Scenario Development

In the scenario development phase, extensive thought was given to the difficulty level and terrain chosen to build the scenario around. Since the goal of this study was to assess recently graduate TBS students, a platoon (consisting of three rifle squads) was appropriate since all of the students would be leading platoons, at the lowest level, once graduating follow-on training and reporting for duty. The scenarios were also developed with the fact that these were meant to be quick, undeveloped situations where little planning time was available. A leader develops a mission order referred to an operations order, or Op Ord. This operations order outlines everything from terrain and weather to location of all units in the battle space, and procedures to be conducted in the event of casualties, prisoners of war, and collection of intelligence. For the purposes of this study, we decided to develop an overarching situation report, which is a form of reporting that provides leaders with a quick understanding of the situation at hand. It is a clear and concise report that gives the most pertinent information to allow leaders to execute upon receipt. We decided this would be given at the beginning of the ETDG and for each subsequent scenario the user would be given a situation update; more concise information specific to the current mission. This would allow the user to understand the general situation at hand at the beginning of the simulation and receive updated guidance as they progressed through training.

The terrain chosen was also carefully thought out when developing the scenarios. In a TDG, the map and written or spoken information is all students must base their decisions off of. In a real-world scenario, one may have a topographic map, or state of the art aerial imagery taken within days of the assault. Since we determined the purpose of this study was not to assess students in map reading, though it is still required, we determined desert and mountainous terrain would be most beneficial. Aerial imagery allows students to orient and identify key terrain features quickly to allow more time to determine the best tactical maneuver possible. Sine assessing tactical decision-making is the goal, this places more emphasis on the decisions made without spending too much time on trying to figure out the map. In the end, we developed five scenarios, all at approximately equal difficulty using similar desert and mountainous terrain. Five Marine Corps infantry officers assessed these scenarios, all who have served as infantry platoon commanders, to ensure the tactical nature was sufficient.

4. System Development

The ETDG went through three different versions of development, each one finely tuning aspects of the design while maintaining alignment with the requirements set forth. The system begins with a brief training scenario (situation report) for the user to gain an understanding of the area of operations and their part in the overall mission (see Figure 8). The situation describes the user as an infantry platoon commander operating as a part of offensive company operations. The user is briefed the general enemy composition as well.

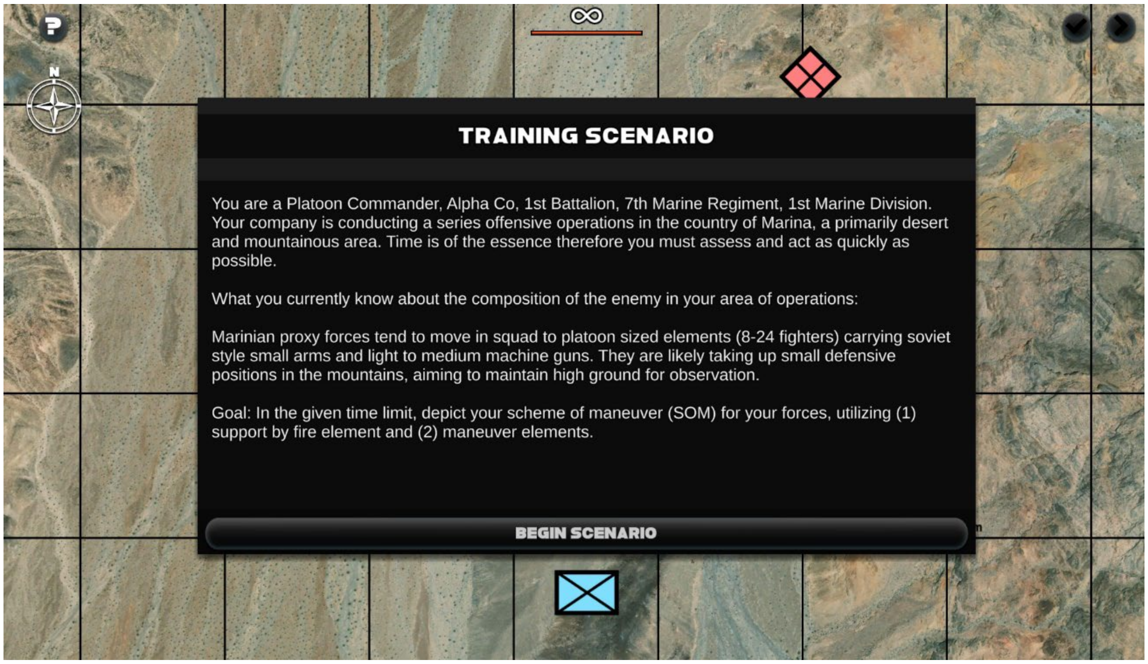


Figure 8. Overarching Situation Report

A quick tutorial is given to allow the user to familiarize themselves with the controls, menus, and features the system offers as well as how they will be evaluated (see Figure 9 and Figure 10). This is an untimed evolution, and the user is able to use as much time as they need to become comfortable with how to play.

Figure 9. ETDG Tutorial_1

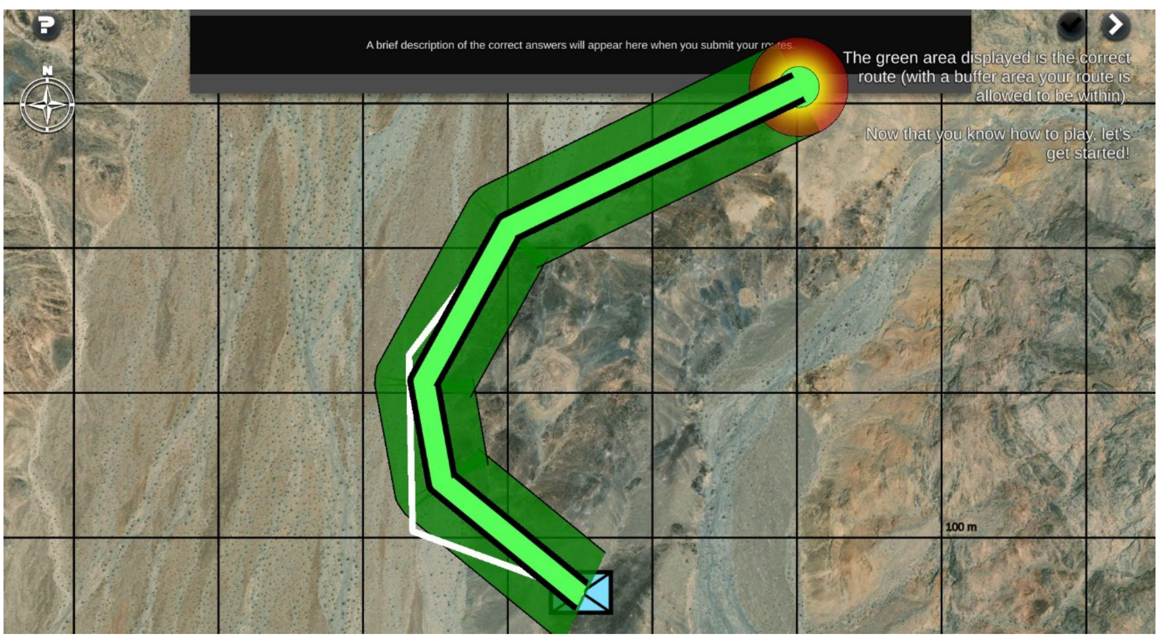


Figure 10. ETDG Tutorial_2

Upon completion of the tutorial, the training scenarios begin. The user will be given a situation update based on the previous information given. They will be asked to complete the given scenario in a certain amount of time. The time will begin after they have clicked "Begin Scenario" (see Figure 11).

Figure 11. ETDG Scenario Description

Once time has run out or the user submits their answer, their work will be graded against a pre-determined answer (see Figure 12). This will be repeated four more times, for a total of five scenarios, given to the user in a random order.

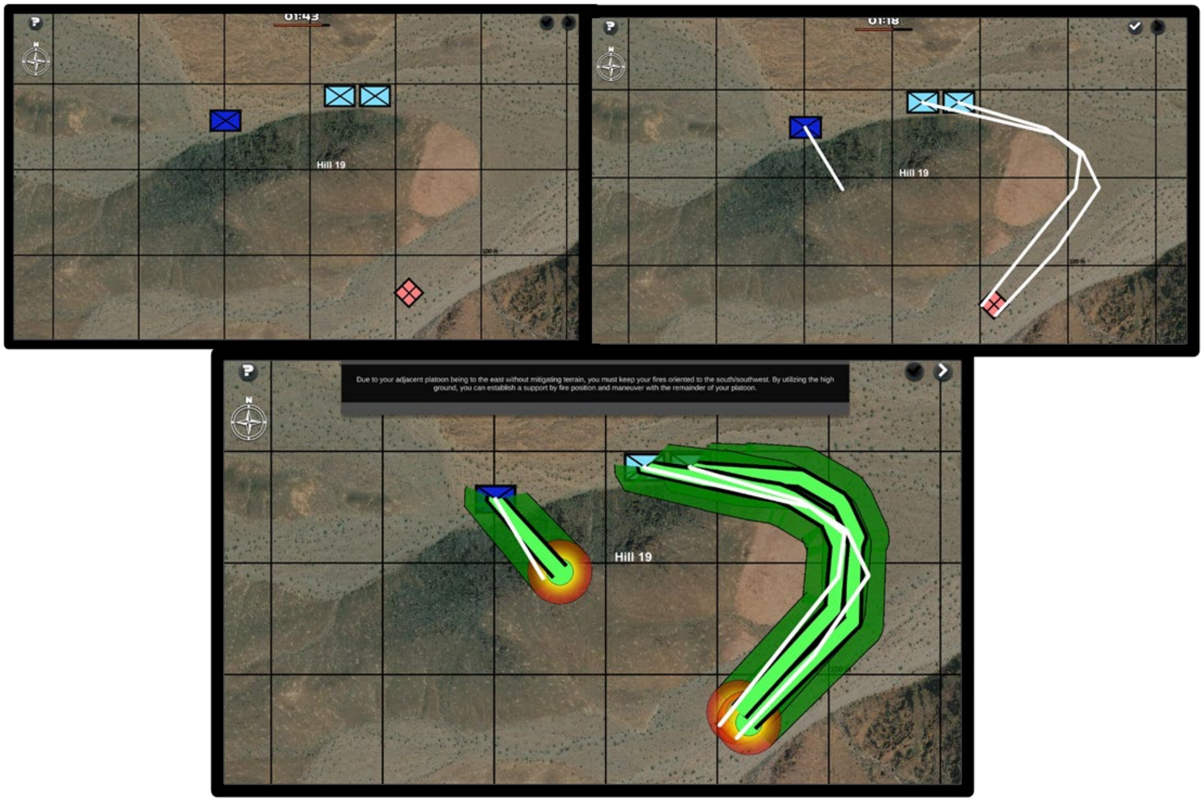


Figure 12. Scenario Sequence

5. Scenario Scoring

Throughout the literature review process, it was noticed that there are myriad ways to score and evaluate students using a TDG. When grading a TDG, instructors tend to have a rubric to work with outlining basic tenets of maneuver warfare, fire support planning, and crew-served weapons employment. In developing the scenarios for ETDG, we made sure to keep in mind that we needed to determine a more objective way of evaluating a fluid and dynamic combat scenario. Looking back at our research questions, we are asking if time and percent of accuracy can be optimized through rapid repetitions in succession, utilizing the principles of the RPD model. In order to accomplish this, we developed a simple algorithm to determine the percentage of time that the users drawn line was off of the deemed correct line of maneuver. The two terms used to describe the movement line and the movement buffer are: route corridor and route render. The thin green line that shows the drawn route in the center of the green shaded is the route corridor. The shaded regions on both sides of the route corridor are referred to as the route render (see Figure 13). Using this method of scoring, the system determines what percent of the time the users' line follows the route corridor, therefore if a student follows the route corridor 75% of the time, that is the score they receive for this portion of the evaluation.

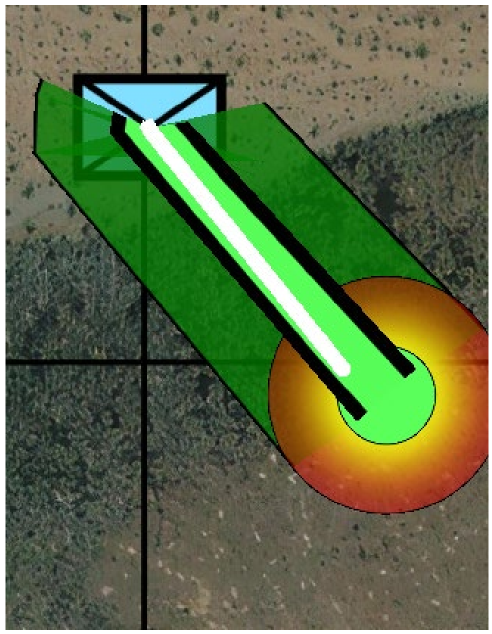


Figure 13. Route corridor and route render

There is a second portion of their score which is dependent on where they stop their drawn line in their maneuver plans. For the support by fire unit, the goal is to stop your units movement at the highest elevation point and as close to a 90-degree offset from their friendly maneuver elements, based on the Marine Corps principles of machine gun employment. When conducting offensive operations, Marine Corps doctrine states assault forces shall continue attacking 100 meters past an enemy objective prior to consolidating. The 'goal bubble,' as seen in Figure 13, shows a green circle in the center and an orange ring around. If the user ends their unit inside the green center, they receive 100 percent for that portion of their scoring. Similarly to the route corridor and render, they receive a percent score on where their unit lands outside of the green circle based on distance from the edge of the green circle. This is done with a simple distance calculation and assigning a percent value. Upon completion of the scenario, both scores are combined to assign one percent value for that scenario. The user is able to assess their scores and an averaging of all scenarios upon completion of all five scenarios (see Figure 14).

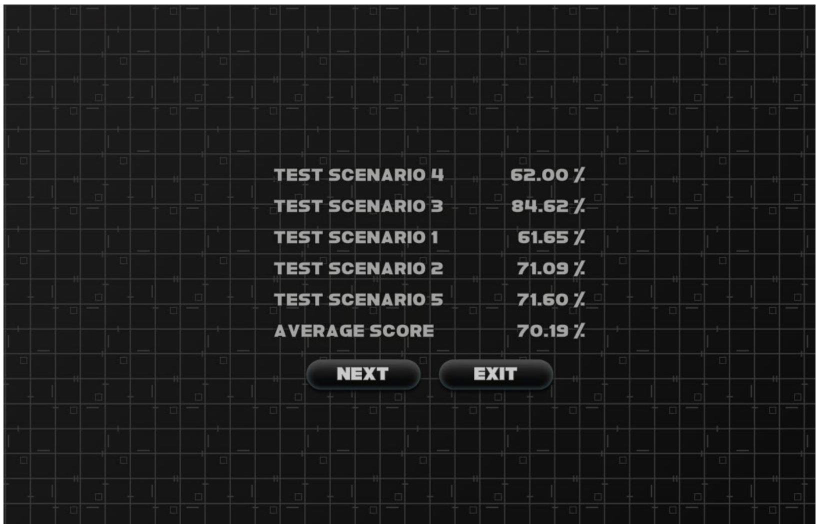


Figure 14. Composite score display

6. Task Summary

The resulting final task design included five TDGs presented three times for a total of 15 TDGs over the course of the study. Each individual would see the same TDGs, but not necessarily in the same order due to them being presented randomly. The user will see the training scenario presented prior to beginning the TDGs. Once they enter training, they will be presented with a situation update based on the specific problem at hand and be asked to draw their scheme of maneuver using one support by fire unit and two maneuver units. Once the time has expired or they have submitted their answer, they will receive an overlay of the optimal choice and a brief description above as to why. They will continue this process four more times. After they have completed the first five TDGs, they will receive their scores for all TDGs and a composite score. This process will be repeated two more times.

C. MATERIALS

The ETDG software was created by the NPS Modeling, Virtual Environments, and Simulation (MOVES) Institute's FutureTech team and was developed in Unity 2020.3.19f1. The scenarios were built by first importing in real-world terrain using a terrain editor and overlaying that terrain with 100-meter gridlines and a north seeking arrow. Enemy and friendly graphics were drawn using the editor, mimicking the commonly used North Atlantic Treaty Organization (NATO) operational terms and graphics. After the participant draws their scheme of maneuver, the application scores their response based on a route corridor and route renderer overlayed over the map. They are assigned a percent value that is logged and exported to a comma separated value (.csv) file for each scenario and shown the overlay with the correct response. The user does not see their percent score until the end of the five-iteration training cycle along with an average score based on all five TDG scores. The participant ID, score for each TDG, and the time to complete each TDG is logged and exported to a .csv file for data analysis.

1. Surveys

This study used three surveys throughout the execution: a demographic survey, a system usability scale (SUS) survey, and a post-task survey.

a. Demographic Survey

The demographic survey for this study collected data about the participants' age, sex, military service, and type and duration of video game play (See Appendix A. Demographic Survey). The purpose of this survey is to facilitate a description of the demographics of the sample and study the impact, if any, that individual military experience or video game usage had on the performance of participant in the study. Participants answered the questions on a printed-out form and responses were manually entered into a computer by the student researcher.

b. System Usability Scale (SUS) Survey

In order to understand the ability of users with a wide variety of computer-based training aide experience to use and operate the system, we decided to use a simple system usability scale. SUSs have been used since the late 1980s in order to ensure early-stage computing systems are not too complex for the specific demographic they are marketing towards. Since interviews and short-answer surveys give very subjective measure of usability, it was determined that this would provide a more objective lens to view the system by. Based on past experiences with Marine Corps programs, usability has been the key factor in the success or failure of the system due to lack of system training for the training audience and inability to maintain system trainers and maintainers due to regular turnover of billets in key positions. A system will have a higher chance of success if no training is required for users to operate the system. The SUS assigns numerical scores to the responses of the user, and by adding and multiplying by 2.5 the system designers have a value out of a possible 100 points to score the usability of their system (see Appendix B. System Usability Scale [SUS]). Generally, scores above 70 are seen as "acceptable," as depicted by Figure 15 below. Participants recorded their answers on a printed-out form and responses were manually entered into a computer by the student researcher.

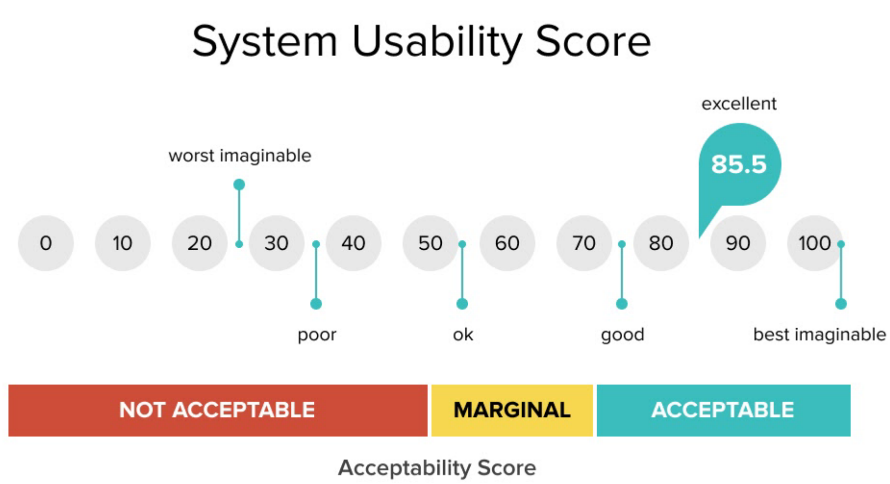


Figure 15. System usability score ranges

c. *Post-Task Survey*

The focus of the post-tasks survey was to collect information on their overall experience with the ETDG throughout the process as well as solicit any recommendations or comments (See Appendix C. Post-Task Survey). The survey focused on the perceived level of difficulty of the scenarios and what aspects of this they found most challenging. The survey also asked whether they believed their performance improved over time and asked to rate their overall performance. This survey also hit at the heart of this study, which was asking if they believe this system would have been beneficial during their entry-level training and whether or not they believe this tool has a place in the operating forces. Participants answered the questions on a printed-out form and responses were manually entered into a computer by the student researcher r.

2. Equipment

This study used two laptop computers to run the ETDG system on and collect data stored by the system in a .csv file. Since the ETDG system does not require any special capabilities and is run through the Unity application, both computers used were typical office type computers capable of running any standard applications. The ability to be run on general-purpose laptop computers was a design decision due to the ability for students to be able to download and use the system on their own personal computer without requiring advanced graphics cards, high-levels of random-access memory (RAM), and high-capacity hard drives.

D. EXPERIMENTAL PROCEDURE

Each participant spent approximately 40–60 minutes conducting the study. Researchers utilized a script (see Appendix D. Session Script) to facilitate each session and standardize throughout the experiment. When the participant arrived for their session they were greeted by a researcher and provided a brief description of the session process followed by providing the participant with the standard informed consent form (see Appendix E. NPS Standard Informed Consent). After the participant has consented to participate, they were then instructed on the completion of the first iteration of five TDGs. Since the ETDG does ask participants to identify directions of movement and orientation, they were given a book of scratch paper to draw or write as needed. As the participant completed the familiarization scenario, researchers would answer any questions on the controls of the system and assist in understanding the user interface. The familiarization scenario does provide the user visual feedback in the form of an overlay that they will see once beginning the training scenario but is not graded. This is only to show them what they screen will look like when they begin. After familiarization, the user began the first iteration of five training scenarios.

Upon completion of the first five TDGs, the user was given the demographic survey to complete. The purpose of giving this survey after they have conducted training is to take their mind off of the TDGs and mentally remove them from the training environment for a few brief minutes. After the demographic survey has been completed, the researcher collected the survey and briefed the participant to click “Begin Scenario” when ready to start the second iteration of five more TDGs.

After the participant has completed the second iteration, they were asked to complete the system usability scale (SUS) based on their experience with the system. It was determined to give participants the SUS after their second iteration because now they have gained some familiarity with the system and would be able to provide information on the use of the system. As with the demographic survey, this is also meant to mentally remove them from the training for a few minutes. When the participant has completed the SUS survey, the researcher collected the survey and briefed the participant to click “Begin Scenario” when they are ready to complete their third and final iteration of five TDGs.

Once the last iteration was completed, participants were asked to complete the final post-task survey and be debriefed on the experiment. The researcher described the purpose and importance of the study and gratitude for their participation. For the participants with questions about the study, the researcher spent approximately five minutes discussing any details authorized at this time. After each participant exited the room, the researcher sanitized the equipment and workstations before the next participant arrived.

IV. PILOT TESTING

Pilot testing was conducted at the Naval Postgraduate School in order to validate the system design, to include the tactical scenarios, verify the data collection was sufficient for analysis, and confirm the experimental procedures to be conducted by the researchers. Seven individuals volunteered to assist in meeting the goals for pilot testing. They were primarily infantry officers with non-combat deployments but varying in the billets they served in. Of the participants, five of them were infantry officers serving in one or more of the following billets: rifle platoon commander, weapons platoon commander, combined anti-armor team (CAAT) platoon commander, company executive officer, battalion assistant operations officer, and company commander.

A. ETDG SYSTEM

The ETDG system performed as expected and users commented on the ease of use, intuitive user interface, and fidelity of the imagery used. The users identified a few difficulties in the ability to assess the elevation of the terrain features on some of the scenarios, so this was adjusted by labeling the key terrain features with numbers such as "Hill 3," which is a widespread practice when depicting terrain on a map during operations. Another concern from a previous infantry school instructor and training officer was the difficulty that might arise with not explicitly stating to students which unit is to be set as the support by fire (SBF) unit. The thought was that if this is meant to be a teaching aide for the maneuver forces, it might make more sense to identify the SBF unit for them. Now, this still requires them to determine the best spot to employ this unit, but it allows the system to maintain maneuver forces as the main teaching aspect. In an effort to not add too much text to the scenarios, it was decided a simple change in shade of color would suffice and ensure this change is described to students in the instructions. These changes, along with minor adjustments to the answer keys, were made by the student researcher using the Unity 2020.3.19f1 personal editor.

B. DECISION-MAKING PERFORMANCE

Since the purposes of this study were to determine if this computer-based system could suggest that users would be able to make decisions with a higher accuracy and in less time, it was necessary to determine if the system was functioning as expected. After using the data collected in pilot testing and analysis through JMP Pro15, it seemed to indicate that the system was functioning as expected (see Figure 16). This data suggested that as users conducted multiple iterations of training with the ETDG, their average time to complete decreased and their score increased.

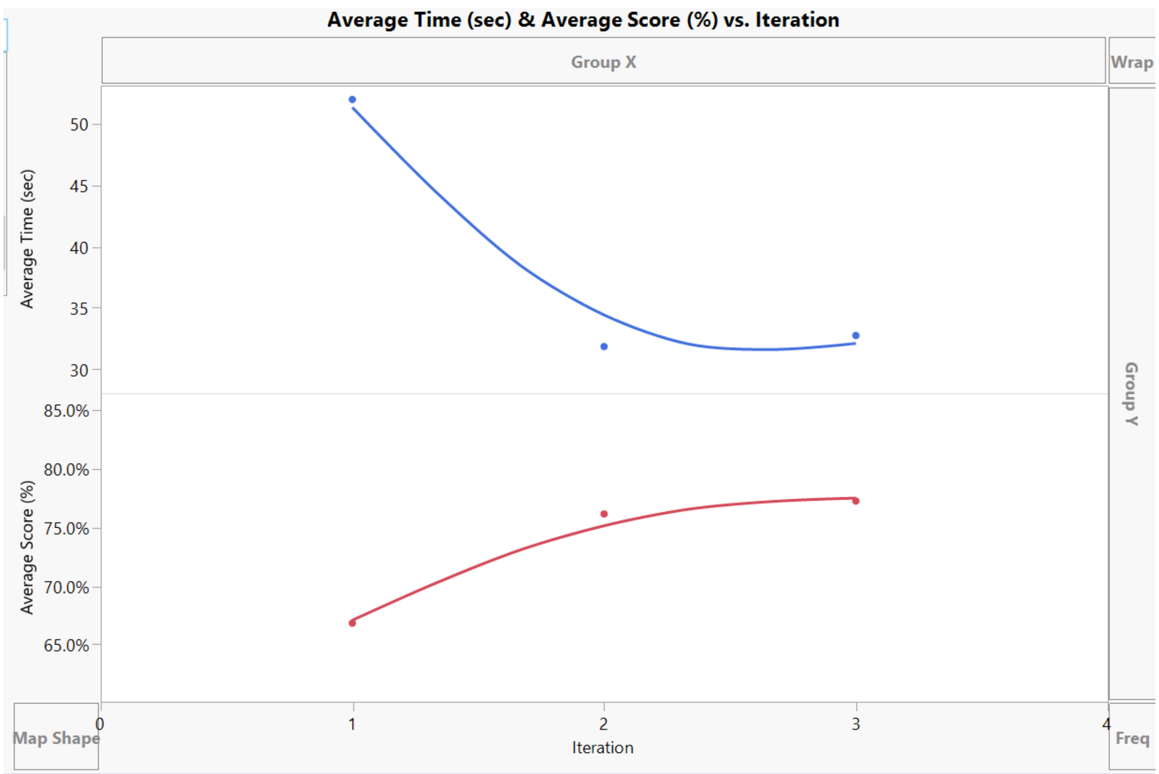


Figure 16. Pilot testing data averages

V. RESULTS

This chapter is organized into three sections. The first section talks about the preparations made prior to forming any conclusions suggested by the data. The second section described the statistical methods used during the analysis of the data collected during the human subjects research. The concluding section provides the results of the experiment with relation to the research questions.

A. DATA PREPARATION

This study utilized two sources for the collection of quantitative and qualitative data: data recorded by the ETDG software and the survey data from participants. The ETDG outputs a .csv file for each participant that includes participant ID, session number (one, two, or three), start/end times for each scenario, and percent score for each scenario. There is also plenty of other data in this file such as number of mouse clicks, route points selected/cleared, and number of times menus were re-opened. None of this supplementary data was analyzed for the purposes of this research. All survey data was filled out on paper forms and compiled into a Microsoft Excel Workbook by the student researcher. The quantitative data from the ETDG .csv files was further prepared using a Python script to calculate time taken to complete scenarios, order of scenarios for each participant session, and percent score for each scenario (see Appendix F. Data Compile Script). JMP Pro 15 was used to analyze the data and generate all related graphs and charts.

B. STATISTICAL ANALYSIS

The statistical method used for hypothesis testing include a one sample *t*-test, analysis of variance (ANOVA), and repeated measures ANOVA. For Research Question 1, Hypothesis 1, the percent score for each scenario that demonstrated acceptable decisions was at least 70%. The average percent score for each session was calculated to analyze the change over time as well as conduct a t test to determine if the data suggests average time to complete is greater than 70%. For Research Question 1, Hypothesis 2, the time to complete each scenario for a participant was collected over time and the average completion time for each session was calculated. Analysis of variance was used to determine if the average time to complete decreased over time.

To test Research Question 2, the qualitative survey data was assessed, and the quantitative SUS data was collected in order to form an average score based on all participants feedback. This was then compared to the generally accepted SUS scale shown in Figure 15.

All assumptions and conditions for the *t*-test were met: independence, randomly selected participants, normal distribution, and a sample size representative of the population. The one-tailed alpha level used was 0.05 (95% confidence interval).

1. Participant Analysis

The participants for this study were all recently graduated students at TBS awaiting training at the Infantry Office Course (IOC) and assigned to the Infantry Prep Platoon (IPP). A total of 27 students volunteered to participate in this study, all of which the rank of second lieutenant. Table 2 and Figure 17 show the summary statistics and the demographic data for the participants

Table 2. Demographic data

Age	*M* = 24, *SD* = 3
Gender	Male: 25, Female: 2
Prior enlisted	Yes: 4, No: 23
Years of Service	*M* = 2.01, *SD* = 3.19, Max = 13
Participants with a Combat Deployment	2

Figure 17. Demographic data

2. Preliminary Results

Descriptive statistics were used initially to gain an understanding of the scenarios that were most and least challenging, according to percent scores and completion times, and identify any outliers in the data. While the average time to complete when looking at all five scenarios was 28.65 seconds and the average percent score was 62.05 percent, Scenario 3 averaged a time of 31.51 seconds and Scenario 5 averaged a score of 58.28 percent. Something that was interesting to discover was through the 'random' ordering of how participants were displayed the scenarios, the order 1,2,3,4,5 appeared five times, whereas the other orders only appeared once or twice. Orders 1,5,3,2,4 and 2,1,3,4,5 both appeared three times as well. All histograms displayed a somewhat unimodal shape with slight left or right tails and very few outliers beyond the outer-quartile range. Figure 18 displays the average time to complete across all scenarios as well as the average combined score in percent. The two outliers remained in the data as they did not cause a dramatic change in the analysis.

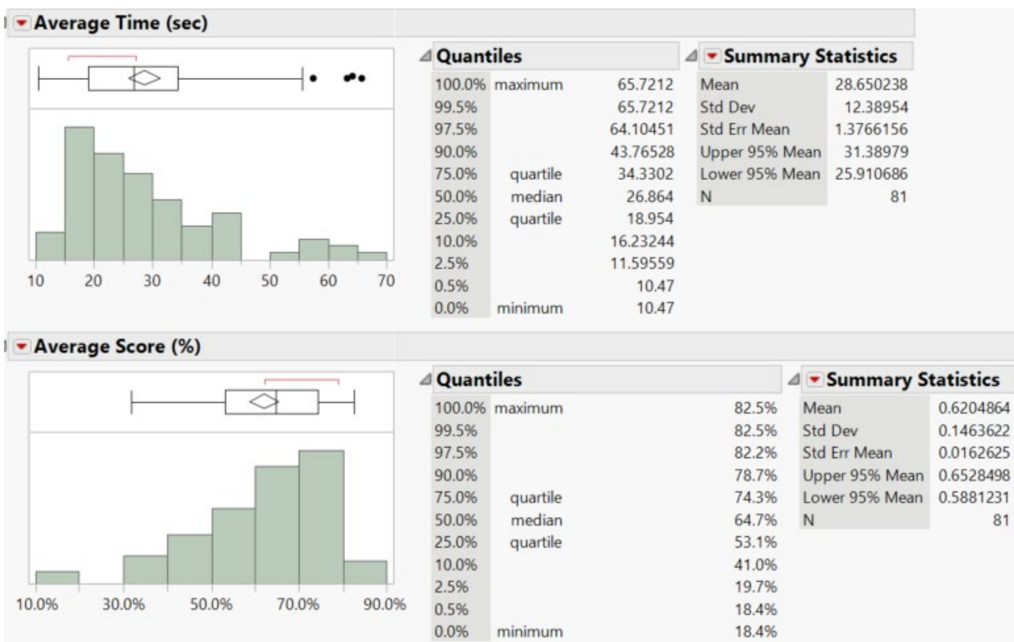


Figure 18. Histograms of average time and score

C. RESULTS ON RESEARCH QUESTION 1

As stated in Chapter I of this thesis, Research Question 1 reads: To what extent can the cycle time from data-gathering to decision-making be shortened via training of platoon decisions on a computer-based simulation? This sections describes the results of the participants who completed the experiment. The goal behind this experiment was to determine if, through rapid repetition, subjects could decrease the time taken to achieve acceptable decisions and reach the 70% solution. Table 3 displays the summary data of average scenario scores and average completion times by session and scenario for all participants.

Table 3. Summary data of scenario scores and times by session

Scenario	Session	Avg Score (%)	Avg Time (sec)
1	1	57.30%	40.03
	2	70.11%	22.79
	3	71.57%	18.08
2	1	50.77%	40.80
	2	62.97%	24.27
	3	67.26%	19.66
3	1	49.08%	38.50
	2	65.36%	30.89
	3	70.55%	25.16
4	1	49.43%	39.16
	2	68.59%	21.52
	3	72.92%	18.57
5	1	43.27%	43.96
	2	63.93%	26.27
	3	67.62%	20.09

As the data suggest, on average, participants reached 70% by the third training session for scenarios one, three, and four while the average score for scenarios two and five did not reach 70%. Based on the survey data and the data above, it is determined that scenarios two and five were more challenging than the other three due to difficulty reading the map using the real-world imagery provided.

1. Alternative Hypothesis 1

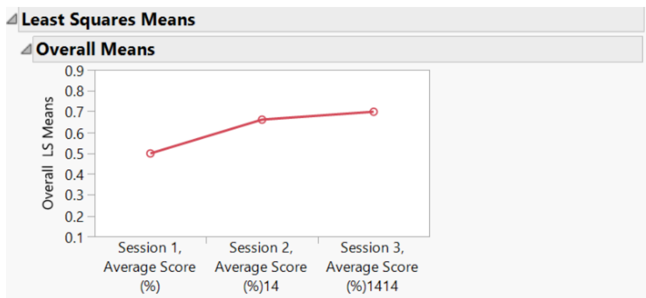
As stated in Chapter I of this thesis, Research Question 1, Alternative Hypothesis 1 reads: Effective training will be demonstrated by participants, on average, selecting acceptable decisions (score of 70%) in the allotted time for each scenario presented, $\mu > .70$. This hypothesis is meant to align with the commonly used term the "70% solution," where Marines are expected to accept an available solution in a time-constrained environment. This implies that, although not the most optimal decision, given the allotted time a Marine has come to a 'good' solution. If the percentage score of participants is too high, then we can conclude the scenarios were too easy, and the opposite is true if many Marines are falling far below the threshold. Of the 27 participants, 17 reached an average of at least 70% during their three training sessions (see Table 4). None of the participants reached mastery on their first training session, 12 participants reached mastery during their second training session, and five participants reach mastery during their third training session.

Table 4. Participants reaching 70% score

Participant ID	Session	Average Score (%)	70% Score Reached?
101	2	70.46%	Yes
101	3	71.94%	Yes
102	2	73.13%	Yes
102	3	77.52%	Yes
105	2	79.78%	Yes
105	3	79.40%	Yes
106	2	75.32%	Yes
106	3	80.02%	Yes
109	2	74.78%	Yes
109	3	74.80%	Yes
200	2	78.71%	Yes
200	3	82.32%	Yes
201	3	77.44%	Yes
202	3	78.39%	Yes
203	2	72.39%	Yes
203	3	70.98%	Yes
204	2	82.47%	Yes
204	3	80.68%	Yes
205	2	75.04%	Yes
205	3	73.72%	Yes
207	2	75.96%	Yes
207	3	78.47%	Yes
208	2	78.48%	Yes
208	3	78.85%	Yes
210	2	75.17%	Yes
210	3	73.22%	Yes
300	3	75.57%	Yes
302	3	72.40%	Yes
303	3	72.80%	Yes

Analysis of variance indicated that there was a statistical difference between sessions one through three, $F(2,25) = 91.64$, $p < 0.001$, $\eta_p^2 = .88$ (see Figure 19). This means that overall there is a difference in overall accuracy among the three sessions. Follow-up *t*-

tests were done to see where those differences were. All three sessions were significantly different from each other; average score on session two was higher than session one, $t(26) = 12.57$, $p < .001$, $d = 2.42$; average score on session three was higher than two, $t(26) = 3.19$, $p = .004$, $d = .61$. As participants conducted repetitions, their average scores tended to increase over time and were statistically significant. When analyzing the ordered differences in Figure 20 we can see that the significant difference in scores occur between session one and session two, with an average increase of 16% in score, as well as session one and three, with in average increase of 20%.



Percent

Test	Value	Exact F	NumDF	DenDF	Prob>F
F Test	7.3312304	91.6404	2	25	<.0001*
Univar unadj Epsilon=	1	121.8716	2	52	<.0001*
Univar G-G Epsilon=	0.8902406	121.8716	1.7805	46.293	<.0001*
Univar H-F Epsilon=	0.9511541	121.8716	1.9023	49.46	<.0001*

Figure 19. Repeated measures results on average score by session

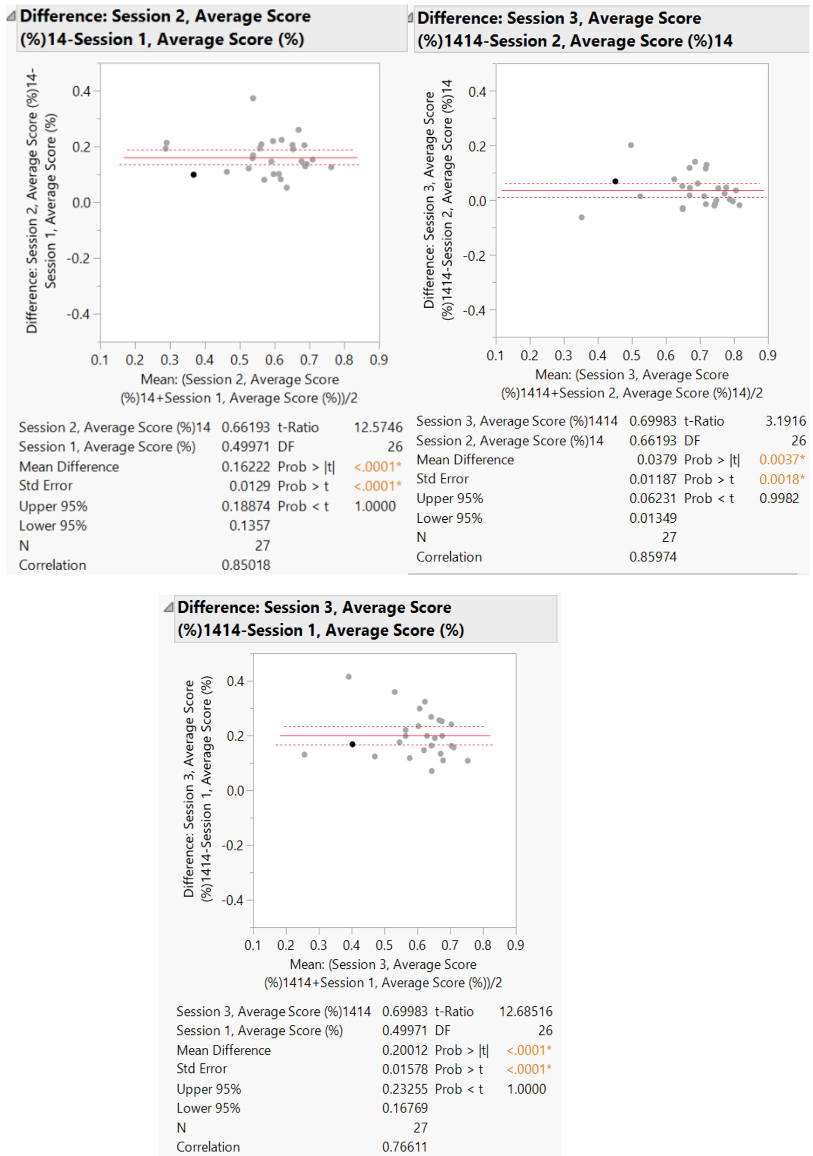
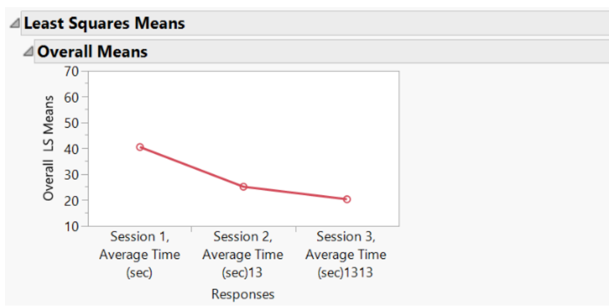


Figure 20. Differences for average score by session

2. Alternative Hypothesis 2

As stated in Chapter I of this thesis, Research Question 1, Alternative Hypothesis 2 reads: Participants experience a decrease in average time to complete TDGs throughout the training iterations, $\Delta\mu time < 0$. The goal of this hypothesis was to see if as participants completed sessions of training their overall time to complete tasks decreased. Marine officers are expected to make good decisions, and quickly, in combat operations. A matter of seconds could result in grave consequences in an ever-changing situation. Figure 21 shows the distribution of average completion times during all three sessions of training on the ETDG. Analysis of variance suggests that there is a statistically significant difference in time to completion between all three sessions, $F(2, 25) = 41.81$, $p < 0.001$, $\eta_p^2 = .77$. Again, this shows a difference in time among the sessions, and follow-up *t*-tests were run to identify where those differences were. There was a significant difference found between each session, with faster times in session two than session one, $t(26) = 7.91$, $p < .001$, $d = 1.52$; and session three faster than session two, $t(26) = 4.29$, $p < .001$, $d = .81$ (see Figure 22). Therefore, we reject the null hypothesis, providing that the data suggests that participants time to complete through repetitions decreased over time.



Time

Test	Value	Exact F	NumDF	DenDF	Prob>F
F Test	3.3445805	41.8073	2	25	<.0001*
Univar unadj Epsilon=	1	68.5680	2	52	<.0001*
Univar G-G Epsilon=	0.7161105	68.5680	1.4322	37.238	<.0001*
Univar H-F Epsilon=	0.7463021	68.5680	1.4926	38.808	<.0001*

Figure 21. Repeated measure results on average time by session

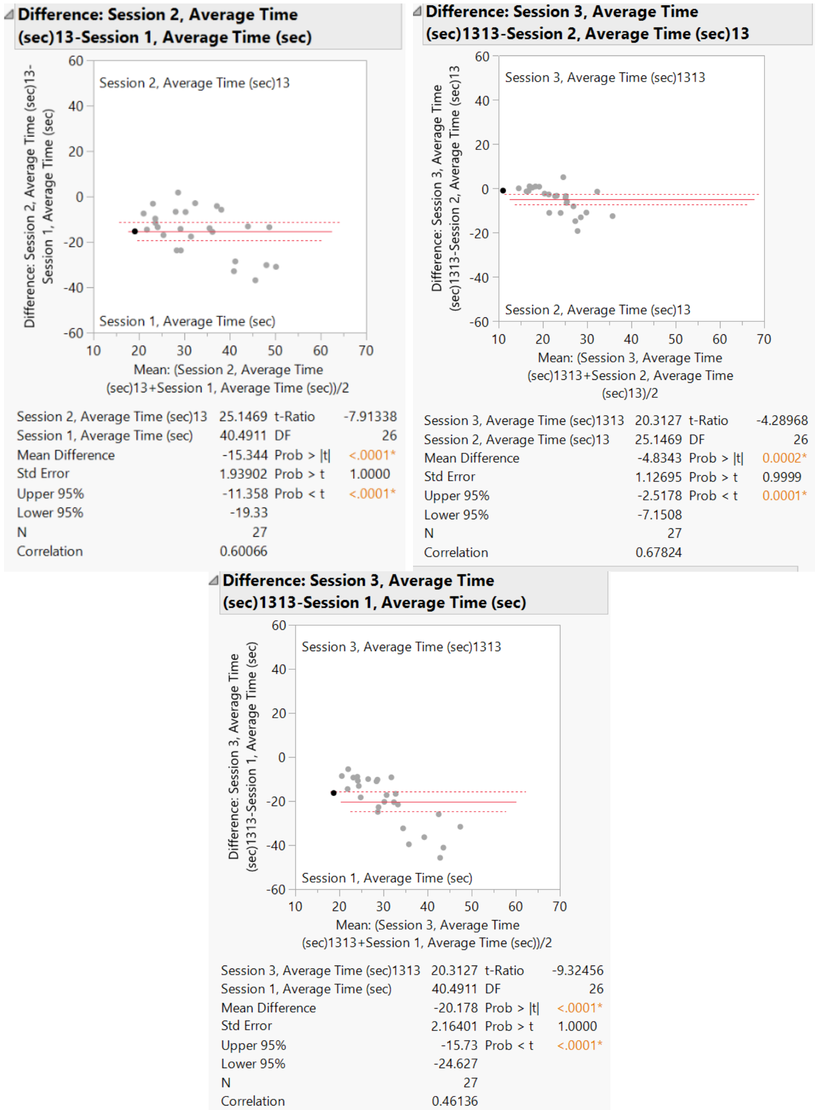


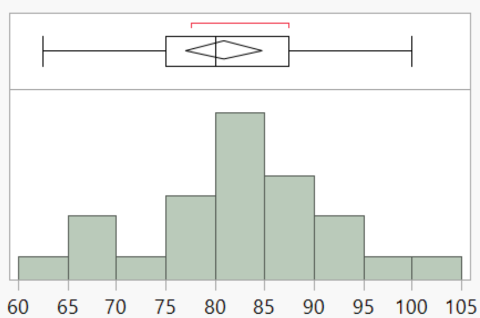
Figure 22. Differences for average time by session

D. RESULTS ON RESEARCH QUESTION 2

As stated in Chapter I of this thesis, Research Question 2 reads: To what extent is a computer-based tactical decision game (TDG) a usable training device for tactical decision making? This research question relied on two surveys in order to collect qualitative and qualitative data: the System Usability Scale (SUS) survey and the post-task survey. The SUS survey (reference Appendix B. System Usability Scale [SUS]) was used to quantify the experience of users and come up with a raw score based on the SUS scale shown in Figure 15. While a number was not hypothesized, generally, an average score above 80 shows an acceptable level of usability as rated by the user. The post-task survey (reference Appendix C. Post-Task Survey) aimed to gain a better understanding of what the users believed were difficulties while utilizing the ETDG as a training tool and ways in which this tool could be enhanced to further enable training for future use. This qualitative data allowed participants to clearly express, in words, what they believe are strengths, weaknesses, and use-cases for this technology.

The SUS survey scores suggest that this system provides a usable solution as a training aid, with the overall average being 80.93 with a standard deviation of 9.99 (see Figure 23).

SUS Score



Quantiles

100.0%	maximum	100
99.5%		100
97.5%		100
90.0%		93.5
75.0%	quartile	87.5
50.0%	median	80
25.0%	quartile	75
10.0%		65
2.5%		62.5
0.5%		62.5
0.0%	minimum	62.5

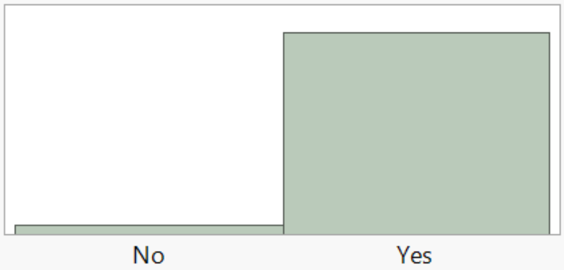
Summary Statistics

Mean	80.925926
Std Dev	9.6612864
Std Err Mean	1.8593154
Upper 95% Mean	84.747804
Lower 95% Mean	77.104048
N	27

Figure 23. System Usability Scale (SUS) results

The data from the post-task survey was used to identify any trends in responses and overall feedback as the system as a training aide, not a replacement for the current program of instruction (POI) at TBS. The first aspect of this was purely subjective questions to the users: did you feel your choices improved over time and would you have liked to be evaluated on a system like this at TBS while learning basic concepts of maneuver warfare? The vast majority of participants in this study answered “yes” to both questions (see Figure 24, Figure 25, and Figure 26).

Do you feel your choices improved through repetitions?



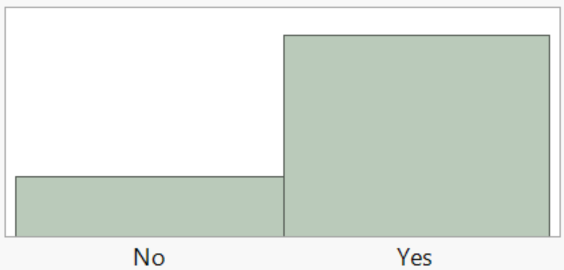
Frequencies

Level	Count	Prob
No	1	0.03704
Yes	26	0.96296
Total	27	1.00000

N Missing 0
2 Levels

Figure 24. Improvement of choices post-task responses

Would you have liked to be evaluated on a system similar to this prior to formal evaluation at TBS?

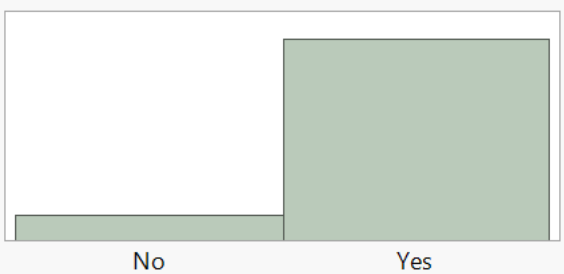


Frequencies

Level	Count	Prob
No	6	0.22222
Yes	21	0.77778
Total	27	1.00000

N Missing 0
2 Levels

Do you believe a system similar to this would allow you to better prepare for a TDG?



Frequencies

Level	Count	Prob
No	3	0.11111
Yes	24	0.88889
Total	27	1.00000

N Missing 0
2 Levels

Figure 25. Preparation for evaluation post-task responses

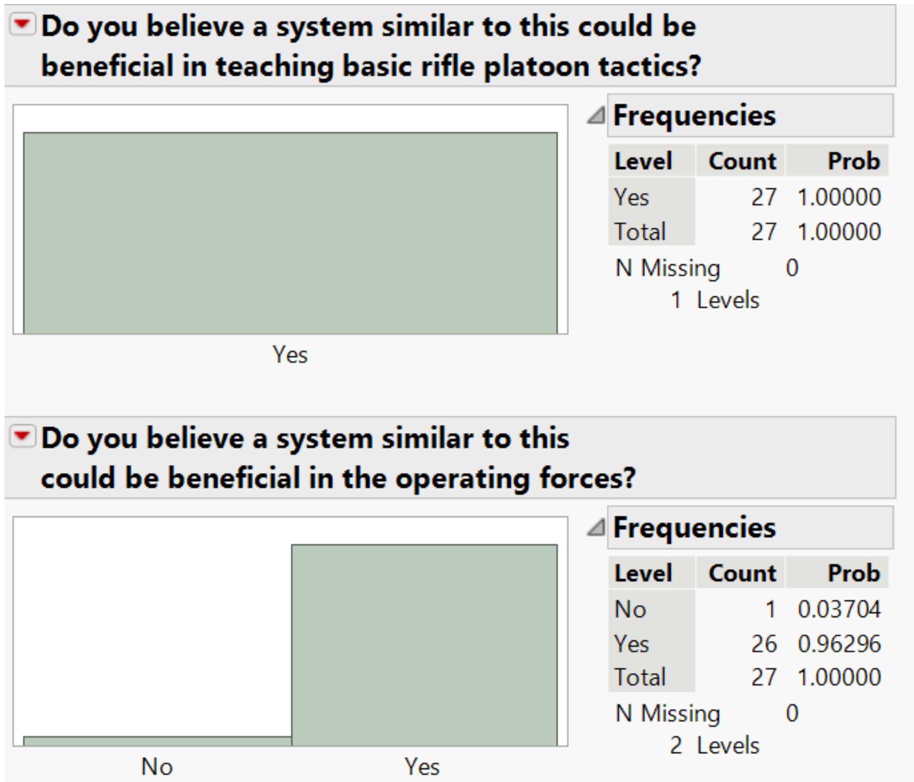
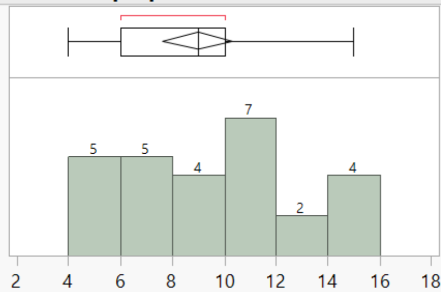


Figure 26. Benefits of system post-task responses

The last thing that the student researcher, specifically, wanted to gain insight on was the number of TDGs/STEXs the students had been asked to prepare for and how many they had actually participated in throughout the TBS POI. With The Basic School graduating approximately 1,700 Marine officers every year during a 28-week POI, it is difficult to evaluate every Marine officer through a TDG/STEX and some may never receive a formal evaluation in this event. According to the data collected from this experiment, on average, students were asked to prepare for approximately nine TDGs/STEXs, with a standard deviation of 3.37. This varied depending on which TBS company the students attended as well as any extra training that was done with their staff platoon commander (SPC), who acts as their direct superior at TBS. The average number of TDGs/STEXs that they were asked to brief and be evaluated was 3.85 with a standard deviation of 1.85 (see Figure 27). The data also shows that there was one participant that was not evaluated on any TDGs/STEXs throughout the POI and three evaluated once.

From what you recall, how many TDGs/STEXs were you asked to prepare or write an order for during TBS?



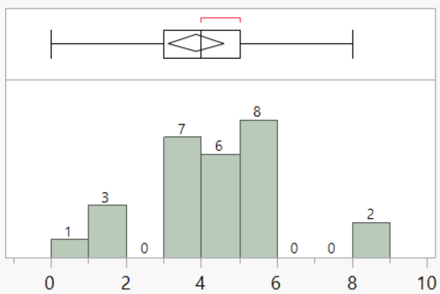
Quantiles

100.0%	maximum	15
99.5%		15
97.5%		15
90.0%		15
75.0%	quartile	10
50.0%	median	9
25.0%	quartile	6
10.0%		5
2.5%		4
0.5%		4
0.0%	minimum	4

Summary Statistics

Mean	9
Std Dev	3.3741096
Std Err Mean	0.6493477
Upper 95% Mean	10.334753
Lower 95% Mean	7.6652467
N	27

From what you recall, how many TDGs/STEXs were you asked to brief and be evaluated on during TBS?



Quantiles

100.0%	maximum	8
99.5%		8
97.5%		8
90.0%		5.6
75.0%	quartile	5
50.0%	median	4
25.0%	quartile	3
10.0%		1
2.5%		0
0.5%		0
0.0%	minimum	0

Summary Statistics

Mean	3.8518519
Std Dev	1.8543857
Std Err Mean	0.3568767
Upper 95% Mean	4.5854224
Lower 95% Mean	3.1182813
N	27

Figure 27. TDGs/STEXs prepared and briefed at TBS

This experiment is by no means criticizing the POI, staff, or instructors at The Basic School. This experiment did not obtain any data on the content of the courses or teaching of tactics, but solely aimed to determine a potential gap in training and developing a solution to assist in the training of Marine officers. This data suggests that there is a need for a training aid to assist in the evaluation of Marines through a computer-based TDG.

VI. CONCLUSIONS

This chapter is organized into four sections. The first section is the summary of the results of this research. The second section discusses the limitations of the ETDG. The third section discusses potential future work for this system and related research. The fourth and final section highlights the need for repetitions in training and the value added in utilizing the technology of today to prepare for tomorrow's battles.

A. SUMMARY OF RESULTS

The primary focus of this thesis was twofold: to assess the viability of increasing the speed and quality of decision-making through repetition and to determine if a computer-based TDG could be developed with the ease-of-use necessary for continuous use. The former focused on developing a system capable of providing users immediate feedback on a maneuver plan, given a friendly and enemy situation and a mission. The latter aimed to receive valuable user feedback on the application's functionality and use-cases in a training and education setting.

The concept behind the ETDG was to leverage today's technology to modernize a well-established military training and evaluation too, the tactical decision game. The ETDG evaluated participants in five different scenarios presented three times each, totaling 15 TDGs throughout the experiment. Participants were asked to draw the scheme of maneuver they believed most closely aligned with sound tactical doctrine and were evaluated by a scoring algorithm to give them a tangible percent score. This study aimed to see participants maintaining an average score of 70% throughout training, with a decrease in time to complete scenarios between sessions. Of the 27 participants in this study, 17 reached an average score of 70% or higher throughout the three sessions, with the average after session one being 49.97%, session two being 66.20%, and session three being 69.98%. Not only did scores increase over time, but the average time to complete each scenario also experienced a decrease. The average time to complete between session one and two decreased by15.34 seconds and decreased by 4.83 seconds between session two and three.

Additionally, a post-task survey was used to analyze the usability of the system and obtain qualitative data on the future implementation of the ETDG. Scoring an 80.93 on the system usability scale suggests that the system obtained the level of usability that was intended. Furthermore, 21 participants wish they would have had a system similar to this prior to formal evaluation and all 27 participants believe a system similar to the ETDG could be beneficial in assisting in teaching rifle platoon tactics.

B. LIMITATIONS

The ETDG is not a perfect system nor is it a replacement to pre-existing training. The concept behind the ETDG was to create a training aide and would not remove the need for instructors and proctors for further expanding concepts in a tactical decision game.

One of the advantages of TDGs in the military is the ability to have more than one 'correct' answer. At this phase of development of the ETDG, there is only one correct answer given to evaluate participants. This was done by bracketing the participants into one correct direction of attack and maneuver using tactical control measures (TCMs) and friendly positions lacking "mitigating terrain" to reduce the chance of fratricide. While this may work as an educational tool in order to teach entry level officers basic tactical maneuvers and formations, this removes any creativity when solving a unique problem. Since the ETDG was meant to provide immediate feedback in a rudimentary, objective sense, this way of developing the scenarios achieved that goal.

C. FUTURE WORK

This section intends to describe ways in which this research could be expanded and other avenues to explore in ways that were outside of the scope of this study.

1. Modify the Scoring Algorithm

There is plenty of literature and prior theses that have implemented pathfinding algorithms given a specific piece of terrain, enemy location, and location of friendly forces. Utilizing artificial intelligence to evaluate participants not only on their maneuver path, but also placement of forces, economy of force, and weapon to target match could really enhance the experience for students. This could allow users to assess the different effects that could be received depending on how the adjust the way they employ forces.

2. Scale the Task

This task was particularly straightforward and simplistic from a tactical perspective and focused on the platoon level. By scaling the task down to squad or up to company and battalion level, one could reach diverse groups of leaders and engage all levels of experience. Again, this should not function as a standalone training and education aide but could be used in tandem with classroom and practical application instruction.

3. Compare with Other Media

Generally, tactical decision games are conducted as a seminar style game, with a large audience watching as one participant is put on the spot to solve a tactical problem. Due to the nature of TDGs, most are conducted using pencil and paper, dry-erase boards, sand tables, or large terrain models. This allows the option for many people to observe the training and utilize the at-hand supplies to conduct training and education. These tried-and-true methods have worked for a long time, and the old adage "if it isn't broken, don't fix it" still applies. In order to truly validate a computer-based TDG, it must be compared against the alternative and, not only suggest a better solution, but a statistically and drastically significantly better solution.

D. CONCLUSION

Military leaders assume their position and title for the sole purpose of critically thinking and making decisions in fluid, time-constrained environments. Developing the intuition of key leaders is a challenging task, and one that is usually gained through experience. A common phrase heard at the Infantry Officer Course is, "What now lieutenant?" As the Marine in charge at any level, subordinates will look to you for a decision. Therefore, it is essential that leaders are able to assess the situation, analyze their options, make a decision, and act on it in a fluid, concise manner. Deliberate practice and meaningful training will allow leaders to gain the experience necessary to make those decisions when the time comes.

This thesis utilized a common purpose laptop and a basic application to develop a computer-based TDG capable of providing leaders with the repetitions needed to hone their decision-making skills. With the technology of today, our military has the ability to be much more capable than previous decades. We must leverage automation to produce rapid repetition training and education platforms that do not require high-speed gaming software, btu commonly owned digital platforms. This study assessed the viability of training a platoon decision-making task to improve the quality of decisions and decrease the time to make them. As MCDP 1-3 Tactics (1997b) states, "We must be faster than our opponent. This means we must move fast, but, more importantly, we must act faster than our enemy. The aim is to tailor our tactics so that we can act faster than the enemy force can react." As we continue to refine and improve our tactical training utilizing today's technology, our aim should be to advance the training of individuals and units across the Department of Defense, so that when war calls, we are ready to answer.

APPENDIX A. DEMOGRAPHIC SURVEY

This demographic survey was modified from Robinette (2021):

Participant Number: ___________________ Date: ______________

1. Age: ________________

2. Current rank:___________________

3. Sex: Male Female

4. Are you prior enlisted? Yes No

    Prior MOS:________ Years Active Duty **enlisted:** _________

    Years Reserves **enlisted:** _________

    c. Years of Service (total): _________

    e. Have you ever deployed to a combat zone? Yes No

    i. If so, what was your billet while deployed? _______________________

5. How often do you play video games?

    Never <2 hrs/wk 2–4 hrs/wk 4–8 hrs/wk >8 hrs/wk

    b. What kind? (circle all that apply)

    None Single-player Multi-player First-person Third-person

    Other:__________________

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APPENDIX B. SYSTEM USABILITY SCALE (SUS)

This System Usability Scale (SUS) was derived from Lewis and Sauro (2009):

System Usability Scale

	Strongly disagree 1	2	3	4	Strongly agree 5
1. I think that I would like to use this system frequently					
2. I found the system unnecessarily complex					
3. I thought the system was easy to use					
4. I think that I would need the support of a technical person to be able to use this system					
5. I found the various functions in this system were well integrated					
6. I thought there was too much inconsistency in this system					
7. I would imagine that most people would learn to use this system very quickly					
8. I found the system very cumbersome to use					
9. I felt very confident using the system					
10. I needed to learn a lot of things before I could get going with this system					

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APPENDIX C. POST-TASK SURVEY

This post-task survey was modified from Robinette (2021):

Participant Number: _____________ Date: ______________

1. How difficult were the scenarios based on your experience?

Very challenging Challenging Neutral Easy Too Easy

2. What made completing the scenarios most difficult? (circle all that apply)

Reading terrain Friendly situation Enemy situation User interface

Other:__________

3. Do you feel your choices improved as the number of repetitions increased? Yes No

4. How confident are you in your overall performance? Low Med High

5. From what you recall, how many TDGs/STEXs were you asked to prepare or write an order for during TBS? __________________________

6. From what you recall, how many TDGs/STEXs were you asked to brief and be evaluated on during TBS? ___________________________

7. Would you have liked to use this at TBS prior to STEXs or graded TDGs? Yes No

8. Do you believe a system similar to this would allow you to better prepare for a TDG? Yes No

9. Do you believe a system similar to this could be beneficial in teaching basic rifle platoon tactics? Yes No

10. Do you believe a system similar to this could be beneficial in the operating forces? Yes No

11. Please provide any other feedback you may have on the system or this study (use the back of the page if you need more space):

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APPENDIX D. SESSION SCRIPT

This session script was modified from Robinette (2021):

Overview and Consent Form (5 minutes)

Welcome to my thesis research study, my name is Alex Fisher. Thank you for volunteering to participate in this study, it will take about 45–60 minutes of your time. This computer-based simulation is called the Enhanced Tactical Decision Game (ETDG). In the simulator, your role is a rifle platoon commander and, given a brief enemy and friendly situation, you will be asked to draw the scheme of maneuver (SOM) that you believe most closely aligns with sound tactical doctrine from your experience at The Basic School (TBS) using a support by fire squad and two maneuver squads. After you finish, if you are interested, I will provide an explanation of what I am trying to do with the study.

I have a couple documents for you to review and sign prior to beginning the experiment. Before we start, I want you to know your participation is strictly voluntary and there is no penalty if you decline to participate at any time throughout this experiment.

The first document regards providing consent to participate in the research. Please take some time to review the consent form and let me know if you have any questions.

Complete ETDG Iteration 1 (10 minutes)

Now you will begin the first of three iterations consisting of 5 TDGs each (total of 15 TDGs). You will first see a tutorial screen to allow you to familiarize yourself with the controls. Take as much time as you need and if you need more time please let me know. Following the tutorial you will begin for first TDG in the first iteration. As I said, there will be 5 TDGs randomly generated for you to conduct within the given time limit. Remember to read the instructions carefully and let me know when you have finished the first 5 TDGs, you will be prompted with a completion window and average scores. Do not worry about the percentages you see; this is all based on a scoring algorithm and the score is not directly tied to your knowledge of the subject. When you are finished please be sure to press "Next" and let me know you are done. You may begin when ready.

Demographic Survey (5 minutes)

This second document is a demographic survey for you to fill out. Please fil it out to the best of your ability and let me know if you have any questions.

Complete ETDG Iteration 2 (10 minutes)

Now you will begin the second of three iterations consisting of 5 TDGs each (total of 15 TDGs). Again, you will first see a tutorial screen to allow you to familiarize yourself with the controls. Take as much time as you need and if you need more time please let me know. Following the tutorial you will begin for first TDG in the second iteration. As I said, there will be 5 TDGs randomly generated for you to conduct within the given time limit. Since these are randomly generated, you may see the same TDGs and possibly in the same or different order. This has nothing to do with your past performance. Remember to read the instructions carefully and let me know when you have finished the 5 TDGs, you will be prompted with a completion window and average scores. Do not worry about the percentages you see; this is all based on a scoring algorithm and the score is not directly tied to your knowledge of the subject. When you are finished please be sure to press “Next” and let me know you are done. You may begin when ready.

System Usability Scale Survey (5 minutes)

This third document is a system usability scale survey for you to fill out. Please fil it out to the best of your ability and let me know if you have any questions.

Complete ETDG Iteration 3 (10 minutes)

Now you will begin the third of three iterations consisting of 5 TDGs each (total of 15 TDGs). Again, you will first see a tutorial screen to allow you to familiarize yourself with the controls. Take as much time as you need and if you need more time please let me know. Following the tutorial you will begin the first TDG in the third and final iteration. As I said, there will be 5 TDGs randomly generated for you to conduct within the given time limit. Since these are randomly generated, you may see the same TDGs and possibly in the same or different order. This has nothing to do with your past performance. Remember to read the instructions carefully and let me know when you have finished the 5 TDGs, you will be prompted with a completion window and average scores. Do not worry about the percentages you see; this is all based on a scoring algorithm and the score is not directly tied to your knowledge of the subject. When you are finished please be sure to press “Next” and let me know you are done. You may begin when ready.

Complete Post-Task Survey (5 minutes)

This final document is a post-task survey to ask some questions about the tasks and any additional comments are much appreciated.

Debrief (5 minutes)

Explanation of Study

I am attempting to verify the usefulness of military training aides on easy-to-use, readily available platforms. My thesis is to demonstrate that an individual’s recognition primed decision-making can be improved through the completion of numerous repetitions of a training aide such as the Enhanced Tactical Decision Game. Since TDGs require lots of work on the part of the one proctoring it, an easy-to-use solution that provides immediate feedback would allow students and Marines in the fleet to conduct rapid repetitions on their own and self-study to perfect their craft. Ultimately, my intent is that this will prepare military leaders to make faster, more optimal decisions by increasing their experience and honing their intuition.

Questions & Answers

APPENDIX E. NPS STANDARD INFORMED CONSENT

Naval Postgraduate School
Consent to Participate in Research

Introduction. You are invited to participate in a research study entitled TESTING COMPUTER-BASED SIMULATION TO ACCELERATE MILITARY DECISION-MAKING IN PLATOON-MANEUVER. The purpose of the research is to test a computer-based simulation platform to assess warfighter performance and shorten the cycle time from data gathering to decision making:

1) Participation is voluntary. Refusal to participate will involve no penalty or loss of benefits to which you would otherwise be entitled, and you may discontinue participation at any time without penalty or loss of benefits to which you otherwise would be entitled.
2) There are no reasonably foreseeable risks or discomforts.
3) Participants will receive no benefits (monetary, food, etc.).
4) The alternative to participating will be not to participate.
5) The requirements for the study include:
   - You will be asked to complete three questionnaires: 1) demographic information, 2) usability of ETDG system, 3) out brief and any specific recommendations for ETDG.
   - You will be asked to read an enemy and friendly situation and, based on the information provided, generate a scheme of maneuver in a given time limit. You will be given a series of five randomly generated scenarios, on three separate occasions, totaling 15 TDGs.
   - We are aiming for 20–50 participants for this study.
   - You will not be audio or visually recorded during this study.
   - This consent form will be the only paper containing any personal information (your signature). I will maintain all consent forms during this study, and while traveling. Upon return to the Naval Postgraduate School, all of these consent forms will be locked in my advisors office.
   - The total time expected to complete this study is not to exceed 90 minutes (estimated 60–90 mins).

The experiment will take place at the Basic School in Quantico, VA. This study will be conducted in one of the barracks common rooms.

Cost. There is no cost to participate in this research study.

Compensation for Participation. No tangible compensation will be given.

Confidentiality & Privacy Act. Any information that is obtained during this study will be kept confidential to the full extent permitted by law. All efforts, within reason, will be made to keep your personal information in your research record confidential but total confidentiality cannot be guaranteed. As described above, myself and my advisor will be the only ones with access to these records and will be kept on our person while traveling and conducting the study and locked in her office upon return to NPS. However, it is possible that the researcher may be required to divulge information obtained in the course of this research to the subject's chain of command or other legal body.

Points of Contact. If you have any questions or comments about the research, or you experience an injury or have questions about any discomforts that you experience while taking part in this study please contact the Principal Investigator, *Dr. Mollie McGuire, 831–656-2995, mrmcguir@nps.edu.* Questions about your rights as a research subject or any other concerns may be addressed to the Navy Postgraduate School IRB Chair, Dr. Larry Shattuck, 831–656-2473, lgshattu@nps.edu.

Statement of Consent. I have read the information provided above. I have been given the opportunity to ask questions and all the questions have been answered to my satisfaction. I have been provided a copy of this form for my records and I agree to participate in this study. I understand that by agreeing to participate in this research and signing this form, I do not waive any of my legal rights.

☐ I consent to participate in the research study.
☐ I do not consent to participate in the research study.

____________________________ ____________________________

Signature of Participant Date

APPENDIX F. DATA COMPILE SCRIPT

```
# Script will calculate, from raw data .csv file, the time and
# score for each scenario and print it out in the order
# scenarios were completed to easily move into excel.
# Author: Alex Fisher
# Date: 17 March 2022
import csv
import json
from operator import contains
import os
from tracemalloc import start

usernameDict = {}
accounts = []
start1 = 0; end1 = 0; time1 = 0; score1 = 0
start2 = 0; end2 = 0; time2 = 0; score2 = 0
start3 = 0; end3 = 0; time3 = 0; score3 = 0
start4 = 0; end4 = 0; time4 = 0; score4 = 0
start5 = 0; end5 = 0; time5 = 0; score5 = 0
fileName = "eventsLog_user305_session3.03-16-2022-114352"

with open(fileName + ".csv," newline='') as csvfile:
   usernameReader = csv.reader(csvfile)
   for row in usernameReader:

       if row [1].__contains__("Start scenario") & row
[2].__contains__("Test Scenario 1"):
           start1 = float(row [0])
       if row [1].__contains__("Score for Scenario Test Scenario 1 (in
%)"):
           score1 = row [2]
           end1 = float(row [0])
           print("Scenario 1 Time: " + str(end1-start1))
           print("Scenario 1 Score: " + score1)


       if row [1].__contains__("Start scenario") & row
[2].__contains__("Test Scenario 2"):
           start2 = float(row [0])
       if row [1].__contains__("Score for Scenario Test Scenario 2 (in
%)"):
           score2 = row [2]
```

```
            end2 = float(row [0])
            print(“Scenario 2 Time: “ + str(end2-start2))
            print(“Scenario 2 Score: “ +score2)

        if row [1].__contains__(“Start scenario”) & row
[2].__contains__(“Test Scenario 3”):
            start3 = float(row [0])
        if row [1].__contains__(“Score for Scenario Test Scenario 3 (in
%)”):
            score3 = row [2]
            end3 = float(row [0])
            print(“Scenario 3 Time: “ + str(end3-start3))
            print(“Scenario 3 Score: “ +score3)

        if row [1].__contains__(“Start scenario”) & row
[2].__contains__(“Test Scenario 4”):
            start4 = float(row [0])
        if row [1].__contains__(“Score for Scenario Test Scenario 4 (in
%)”):
            score4 = row [2]
            end4 = float(row [0])
            print(“Scenario 4 Time: “ + str(end4-start4))
            print(“Scenario 4 Score: “ +score4)


        if row [1].__contains__(“Start scenario”) & row
[2].__contains__(“Test Scenario 5”):
            start5 = float(row [0])
        if row [1].__contains__(“Score for Scenario Test Scenario 5 (in
%)”):
            score5 = row [2]
            end5 = float(row [0])
            print(“Scenario 5 Time: “ + str(end5-start5))
            print(“Scenario 5 Score: “ +score5)
```

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