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GAMING THE SYSTEM: USING DIGITAL TRAINING GAMES TO ENHANCE DECISION-MAKING

Moore, Emily L.

Monterey, CA; Naval Postgraduate School

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THESIS

GAMING THE SYSTEM: USING DIGITAL TRAINING GAMES TO ENHANCE DECISION-MAKING

by

Emily L. Moore

December 2022

Thesis Advisor: Rudolph P. Darken
Co-Advisor: Perry L. McDowell

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GAMING THE SYSTEM: USING DIGITAL TRAINING GAMES TO ENHANCE DECISION-MAKING

Emily L. Moore
Lieutenant, United States Navy
BS, Pennsylvania State University, 2015

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December 2022

Approved by: Rudolph P. Darken
Advisor

Perry L. McDowell
Co-Advisor

Alex Bordetsky
Chair, Department of Information Sciences

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Computer games provide digital training tools; however, their effectiveness requires well-defined learning objectives and realistic scenario development. This thesis addresses how digital training tool Threat Identification Decision Environment (TIDE) could be used to enhance the decision-making of combat watchstanders. United States Navy Information Warfare, Surface Warfare, and Aviation officers at the Naval Postgraduate School played different scenarios provided by the game TIDE. Their performance was evaluated by the game following each scenario providing scores. Score data was assessed for effectiveness of the game in providing training. Through surveys addressing player experience, users deemed it effective training. TIDE is a tool that could be used for developing trained and ready sailors for fleet operations using reusable and deployment ready toolsets meeting the Ready, Relevant Learning requirements.

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LIST OF ACRONYMS AND ABBREVIATIONS

ARG	Amphibious Readiness Group
CDR	Commander
CNO	Chief of Naval Operations
CSG	Carrier Strike Group
CWC	Composite Warfare Commander
ESG	Expeditionary Strike Group
FST	Fleet Synthetic Training
I/ITSEC	Interservice/Industry Training Simulation and Education
JCORE	Joint Cognitive Operations Research Environment
NETC	Naval Education and Training Command
NPS	Naval Postgraduate School
OTC	Officer in Tactical Command
PEO IWS	Program Executive Office Integrated Warfare Systems
RLL	Ready Relevant Learning
SCSTC	Surface Combat Systems Training Command
TIDE	Threat Identification Decision Environment
VOT	Virtual Operator Trainers
VR	Virtual Reality

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I. INTRODUCTION

Models and simulations are not a new concept to the U.S. Navy. Flight simulators for pilots and aircraft personnel are used for the evaluation of skills and contribute to the currency of that personnel. Tabletop wargames have been used at different leadership echelons to train leaders about tactics and their potential effects on both friendly and adversary sides of a fight. These types of exercises are still used today in the training of carrier strike groups during the work-up phase before deployment (Cain, 2019).

Technologically adept sailors have changed the way the Navy approaches training recruits and officers. The surface warfare community has simulators for ship drivers to include virtual reality (VR) headsets used at Basic Division Officer School, in addition to full bridge simulations at the Advanced Division Officer school and Department Head school (Surface Warfare Officers Schools Command, 2016). Decisions based on perceived threat can be practiced through digital training tools and simulations outside of the classified realm of combat watch standing. The U.S. Navy has developed simulators and digital training tools for some of its warfare area-specific training to enhance warfighter proficiency.

The extent of training decision-making skills of information warfare watchstanders but also of surface warfare watchstanders are evaluated through shipboard training scenarios however, the extent to which those skills are maintained and evaluated needs to be specifically defined and evaluated to ensure that digital training tools are effectively being used by the Fleet. This study provides an analysis of digital training; however, further evaluation of performance on board a ship following training is needed to evaluate a sailors' skill development and skill transfer for a scenario.

A. PROBLEM STATEMENT

The Navy needs to develop and implement decentralized training methodologies to train sailors before they enter the Fleet, when they are stationed at their ship or shore-based unit, and while they are deployed. Specifically, the Navy needs to implement digital training tools to increase the decision-making skills of watchstanders in response to potential threats. The increased availability and effectiveness of digital training tools provide a solution that can be tailored to unique situations across the Navy's various warfare domains.

B. RESEARCH QUESTIONS

1. What constitutes effective decision-making in the Information Warfare domain?
2. Can a digital game designed to facilitate deliberate practice on decision-making tasks effectively train sailors on how to conduct Fleet operations?
3. How are reactions to threats measured whether actual or simulated, to assess proper responses?
4. How can digital games training be assessed using the Navy's training checklists and evaluations used for shipboard environment training?

C. THESIS WORK

This study focused on evaluating how a Navy-specific digital training tool can be used in a low-stress, low-risk, digital environment. The digital training environment Joint Cognitive Operational Research Environment (jCORE), developed by Metateq, contains serious games used to train military personnel (Metateq, n.d.). This study used the game Threat Identification Decision Environment or TIDE to train and test Navy personnel on the identification of inbound missile threats to a ship. The game focused on the task of identifying and responding to inbound missile threats over time.

Subjects were given a pre-experiment demographic survey and test to evaluate their prior knowledge of missile threats. Following the test, they were briefed on the general threats they would encounter in the game and then tasked to complete a tutorial scenario for gaining familiarity with the software and gaming environment. Then subjects played through three separate scenarios that had players identify and react to different threats. They were evaluated for performance in making decisions to identify inbound threats.

D. SCOPE

The focus of the study was on evaluating decisions made in a low-stress, low-risk, digitally presented training scenario. The assessment of TIDE provides feedback to both Metateq and the Information Warfare Training community for further evaluation. This study does not include a study of skill transfer from the game to shipboard performance during a real scenario. In the Fleet, sailors are evaluated on board ships during simulated threat scenarios on the equipment used during deployment. Further evaluation of performance on board a ship following training is needed to evaluate a sailor's skill development.

E. OVERVIEW OF THESIS

Chapter II provides a background of the problem including the Composite Warfare Structure, the Navy's current training initiatives, an overview of the science of learning and game-based training, and an introduction to the game TIDE. Chapter III provides the methodology used for this study. Chapter IV provides the results of the experiment using TIDE. Chapter V provides a discussion of the results of the experimental surveys and game data. Chapter VI is a conclusion of the study and future work recommendations.

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II. BACKGROUND

A. STRIKE GROUP OPERATIONS

1. Composite Warfare Command Concept

The United States Joint Maritime Operations Doctrine describes the Navy Composite Warfare Doctrine (CWC) and defines the role of the officer in tactical command (OTC) who "may assign some or all the command functions associated with mission areas to warfare commanders" (Joint Chiefs of Staff [JCS], 2021). Carrier strike groups are comprised of an aircraft carrier, at least one guided missile cruiser, and two or more guided missile destroyers. The concept of command by negation recognizes the distributed nature of operations and delegates some warfare functions to subordinate commanders to take actions pre-planned in without getting express permission from the OTC and delaying response (JCS, 2021). The commander of each of those ships can act to defend the ship or conduct operations such as searching for submarines and launching aircraft without express permission to act from the OTC. For example, combat watchstanders on individual ships report their actions to subordinate warfare commanders such as sea combatant commanders. If there is a threat of an inbound missile individual ships operate on doctrine, and pre-planned responses, and rely on watchstander training to identify and neutralize threats in the maritime area of operations. Layered defense-in-depth within a strike group allows for units to act while maintaining situational awareness of their surveillance areas, classification identification and engagement area, and vital areas (JCS, 2021).

> Surveillance area –In surface warfare, the operational environment that equals the force's ability to conduct a systematic observation of a surface area using all available and practical means to detect any vessel of possible military concern. The dimensions of the surveillance area are a function of strike group surveillance capabilities, sensors, and available theater and national assets. Classification, identification, and engagement area (CIEA). In maritime operations, the area within the surveillance area and surrounding the vital area(s) in which all objects detected must be classified, identified, and monitored; and the capability maintained to escort, cover, or engage. The goal is not to destroy all contacts in the CIEA, but rather to make decisions about actions necessary to mitigate the risk that the contact poses. The CIEA typically extends from the outer edge of the vital area

> (VA) to the outer edge of where surface forces effectively monitor the operational environment. It is a function of friendly force assets/capabilities and reaction time, threat speed, the warfare commander's desired decision time, and the size of the VA. VA. A designated area or installation to be defended by air defense units. The VA typically extends from the center of a defended asset to a distance equal to or greater than the expected threat's weapons release range. The intent is to engage legitimate threats prior to them breaching the perimeter of the VA. The size of the VA is strictly a function of the anticipated threat. In some operating environments, such as the littorals, engaging threats prior to their breaching the VA is not possible because operations are required within the weapons release range of potential threats. Preplanned responses should include measures for when contacts are initially detected within the VA. (JCS, 2021)

A watchstander's ability to recognize an inbound threat, identify it, and take proper action against it is critical to the defense of not only a single ship but of the entire strike group. A watchstander must be aware of the basics of identification based on electronic signature or lack thereof, and the proper response to fight the ship. Basic pre-planned responses promulgated through warfighting doctrine can establish a sailor's entry-level knowledge at the beginning of their training as a combat watchstander. Both enlisted sailors and officers must know the basics of threat identification. Speed of reaction to a threat could mean the difference between maneuvering the ship out of the line of danger and a hole in the hull of the ship and loss of sailors' lives.

B. CNO DIRECTED PRIORITY TRAINING

Chief of Naval Operations (CNO) Admiral Michael Gilday emphasized the training of sailors in A Design for Maintaining Maritime Superiority. In the Design for maintaining maritime superiority 2.0, the CNO specifies expanding live, virtual, constructive training to support the needs of scale, complexity, and security of training and operations (United States Navy [USN], 2018). These trainings include realistic and accurate experience in secure environments at all levels of training (USN, 2018). The document also includes the need to coordinate efforts with academia to integrate decision science to improve decision-making (USN, 2018). In efforts to achieve the end state of a trained and ready warfighting force, the Ready Relevant Learning (RLL) initiative was launched to ensure that U.S. Navy Sailors are trained better than their Chinese and Russian counterparts (Gilday, 2020).

1. Vision and Guidance for Ready Relevant Learning 2021

Naval Education and Training Command (NETC) was tasked with the RLL initiative and established its vision and guidance. In terms of guidance, NETC focuses on modern delivery of training at the point of need. This helps to minimize sailors' training time at brick-and-mortar schoolhouses, which takes them away from their unit's manpower, and increases their exposure to on-the-job training they would get in the Fleet (U.S. Fleet Forces Command [USFF], 2016). One of the goals of Ready Relevant Learning is to align the training of sailors with deck plate needs, "efficiently with time, when they have context and experience to apply learned skills" (USFF, 2016). Additionally, another goal is to ensure that their knowledge is:

> Refreshed to remain relevant in dynamic operational environments with evolving platform capabilities and emerging warfighting technologies…Knowledge and skills atrophy through lack of use is minimized when sailors can access proper training tools and information… By increasing the accessibility of training by moving courses and resources to accessible platforms for sailors both pier side and underway would significantly reduce time, cost, and operational impacts to units and their readiness. (USFF, 2016)

Through a three-stage approach, the RRL initiative is set to be complete by 2025. In Stage 1, block learning, sailors go to their first unit without full technical knowledge following basic training and rating schools. They receive on-the-job training for their rate and gain experience with their units. The reported completion of stage 1 occurred in 2022 (Naval Education Training Command [NETC], 2022).

Moving towards enhanced accessible learning in stage 2. In stage 2 sailors would not be required to leave their commands to attend rate-specific schoolhouses for training and could conduct self-directed training and receive support at their duty stations, with the option to attend instructor-facilitated training at local training centers (NETC, 2022).

The goal for stage 3 is a modernized, on-demand, Fleet-responsive training. In this stage, all content will be accessible to sailors where and when they need it including underway (NETC, 2022). Additionally, new training will be delivered faster than current systems and processes allow. Thus, these modern systems will provide sailors with the opportunity and capability to remain flexible and access training from anywhere in the world (NETC, 2022).

2. U.S. Navy and Marine Corps United on Training Efforts

At the 2021 Interservice/Industry Training Simulation and Education Conference (I/ITSEC), CNO Admiral Michael Gilday and Commandant of the Marine Corps General David Berger focused on learning and training integration, as well as development of servicemembers. Both leaders emphasized, "sets and reps," on weapons systems, and on platforms to "train our leaders to think" and "outthink the adversary" (United States Navy [USN], 2021). These series of repetitions of an exercise during training help enforce the knowledge sailors and marines gain and use in the Fleet. Repeating the exercise reinforces what factors should be considered and the decisions that should be made when faced with a situation requiring action to outmaneuver the adversary (USN, 2021).

General Berger stated to two challenges: one addressing modeling and simulation and two how to "drive leaders to think" against the adversary (USN, 2021). For example, he stated that an assessment of capabilities and tactics is required to create models and simulations to accurately depict a near-peer adversary. General Berger placed emphasis on warfighting proficiency, identifying individual and team deficiencies, and addressing them through training. "In teaching leaders of sailors and marines, those tools must be developed with advanced concepts in mind. A leader who can leverage their assets and training in decision-making is more likely to be adept in problem-solving" (USN, 2021).

3. COVID-19 Impacts to Fleet Training

The COVID-19 Pandemic forced training and education to adapt across the world. In an article addressing training centers, Lundquist noted that due to restricted movement of personnel and social distancing requirements, Navy training was limited, for example, by the numbers of personnel allowed in classified spaces or classrooms (Lundquist, 2020). This led to innovation and the use of personal computers for telework, video conferencing, and distance learning including command training (Lundquist, 2020). Lundquist stated that training personnel noted how distance learning allowed for some flexibility in the delivery of material to students. However, the classification of certain topics remains a hurdle for finding appropriate space and connectivity. Government networks still provide the means of conducting secure teleconferencing to conduct courses and training (Lundquist, 2020). This allows a course taught in Norfolk, Virginia to be accessed by personnel in Yokosuka, Japan, through proper recording and sharing on secured servers that can be shared globally.

4. Warfighting Proficiency and U.S. Navy's Current Digital Environments for Training

The Navy's current simulators and digital environments are located across the country in Fleet concentration areas. Some are collocated with brick-and-mortar schoolhouses where sailors and officers attend resident courses critical to their careers. The Program Executive Office Integrated Warfare Systems 5.0 (PEO IWS 5.0) and Surface Combat Systems Training Command (SCSTC) are responsible for bringing Virtual Operator Trainers (VOT) to Fleet training centers increasing the number of "sets and reps" for sailors (Lansdale, 2022). PEO IWS develops anti-submarine warfare capabilities and delivers undersea warfare training. These VOTs align with the RRL program, bringing innovative technological training capabilities to the sailors on the waterfront (Lansdale, 2022). SCSTC enables the training of sailors globally with 12 locations to train warfighters throughout all phases of surface combat systems deployment (Naval Education and Training Command, n.d.).

Enabling Fleet-level training is essential to training a carrier strike group (CSG), amphibious readiness group (ARG), and expeditionary strike group (ESG) to operate together (Lammons, 2020). Live at-sea exercises are far from being replaced by virtual training but are enhanced by technological developments and pier-side networking capabilities. Fleet Synthetic Training (FST) is a virtual training environment where ships can train together without being at sea. Strike group staff and warfighters can train in real time regardless of location in the same scenario (SAIC, n.d.). FST incorporates all warfare areas and provides tactical-level training across different platforms. Additionally, FST can incorporate joint and partner nation training into its scenarios. FST enables the Fleet to train and reinforce knowledge through complex real-time scenarios that are critical to the maritime operational environment.

The Large Scale Exercise 2021 was an effort to incorporate global live, virtual, and constructive training as a part of the CNO and CMC's efforts (Lagrone, 2021). The exercise incorporated multiple units worldwide with both simulated and computer-generated scenarios as well as deployed units that were linked together. The training incorporated sailors at watch stations as well as admirals and their staffs, to coordinate in response to simulated threats and tensions (Lagrone, 2021). These globally connected training scenarios are one way of training the Fleet and working with technological advances to connect warfighters, hone and evaluate their skills, and prepare them for operations.

C. SCIENCE OF LEARNING

1. Task Analysis

Task analysis is a "collection of data about a job or group of jobs to determine what an employee should be taught and the resources he or she needs to achieve optimal performance (Klein & Calderwood, 1991)." In the case of Navy training, the knowledge of operating a weapons system has many sub-tasks and information that a sailor must know to understand and operate the system. Cognitive task analysis is "an extension on task analysis techniques to yield information about knowledge, thought processes, and goal structures that underlie observable task performance (Schraagen et al., 2000)." By collecting data about what the subjects knew before the experiment we could analyze their procedural knowledge. Procedural knowledge refers to the knowledge of how to perform a specific task (Kim et al., 2013). In the case of our experiment identify a missile and then deploy the correct weapon to neutralize it. Procedural knowledge differs from declarative knowledge in that the latter is the knowledge that describes, things, events, or processes; their attributes, and their relation to each other (Kim et al., 2013). In the study, most of the personnel had a conceptual knowledge of how defense-in-depth of a strike group and defending a ship works without knowing the specific defense procedures. Hence, when they started, personnel already had declarative knowledge of the subject matter.

2. Dreyfus Model of Adult Skill Acquisition

Stuart E. Dreyfus and Hubert L. Dreyfus collaborated on a "Five-stage model of adult skill acquisition," as illustrated in Figure 1. According to Dreyfus and Dreyfus, each learner passes through the following stages as they learn: novice, advanced beginner, competence, proficiency, and expertise (Dreyfus, 2004). Stage 1 novices are new to learning the desired skill. Instructors break down the task and provide the novice with a rules-based approach for determining actions. Simply having the facts will give context for the environment; however, the novice must learn to understand the information to make the proper decisions. Stage 2 advanced beginners have experience with scenarios and understand the context. They learn to recognize additional features in a situation and continue to learn through instruction and examples (Dreyfus, 2004). Stage 3 competence is achieved when faced with the full spectrum of elements in a situation and learns through their understanding of the rules to consolidate their focus. Further elements of competent learners involve risk and taking responsibility for one's actions analyzing the successes and failures. Stage 4 proficiency is further based on the learner's experience and ability to discriminate between various scenarios. The experienced performer sees goals and aspects of a situation, but not what to do to achieve the goals and still must decide what to do (Dreyfus, 2004). Stage five expert is based on vast experience. An expert understands what needs to be achieved and how proceed immediately (Dreyfus, 2004).

Skill Level	Components	Perspective	Decision	Commitment
1. Novice	Context free	None	Analytic	Detached
2. Advanced beginner	Context free and situational	None	Analytic	Detached
3. Competent	Context free and situational	Chosen	Analytic	Detached understanding and deciding; involved outcome
4. Proficient	Context free and situational	Experienced	Analytic	Involved understanding; detached deciding
5. Expert	Context free and situational	Experienced	Intuitive	Involved

Figure 1. Five Stages of Skill Acquisition. Source: Dreyfus (2004)

3. Recognition Primed Decision-Making

Recognition Primed Decision-Making is a decision model proposed by Klein and Calderwood (Klein and Calderwood, 1991). The model shows how decisions are made in complex scenarios. The decision-maker is assumed to have a basic level of knowledge about the problem or experience with a particular scenario and can generate a course of action, compare it to the challenges within a scenario, and act (Klein and Calderwood, 1991). Experts studied by Klein were able to make a fast effective decisions to solve a problem.

In the TIDE study, individuals' level of knowledge of missile threats was evaluated in the pre-test. Within the TIDE game, knowing the types of sensors of inbound threats and the weapons used to defeat them can be beneficial.

D. GAME BASED TRAINING

1. Gamification

Gamification is defined by Karl Kapp as "using game-based mechanics, aesthetics, and games to engage people, motivate action, promote learning, and solve problems" (Kapp, 2012). Gaming elements can make training more engaging and provide an aspect of fun and competition in the learning process. Incorporating elements like storytelling and feedback with the freedom to fail in scenarios can be more engaging to learners. Succeeding in engaging with learners can result in better skill development (Kapp 2012). Elements of competition in games drive learners to outperform others in scenarios where a scoreboard is posted highlighting outstanding performance. A fun learning experience is a benefit of gamification of training.

2. Serious Games

Serious games are defined as "any form of interactive computer-based software for one or multiple players to be used on any platform that has been developed to be more than entertainment (Cody et al., 2009)." Training games such as TIDE simulate threats and real-world decision-making without the risk to personnel and equipment. There are realistic components to TIDE which translate to operations on a ship in combat. These "realisms" within the game help train and develop skills that could carry over to the shipboard environment.

3. Previous Games Research

U.S. Navy Commander (CDR) Daniel Cain researched the use of serious games to train officers on a Navy operational staff. He studied the ability to train personnel with limited experience in an operational command using digital scenarios and evaluated their performance in scenarios (Cain, 2019). The overarching goal of training personnel with limited experience and varying backgrounds on a staff is to ensure that they can execute operations as a team when deployed. Serious games can provide a different method of training personnel and give practical exposure through scenarios to the trainees (Cain, 2019).

Another study involved the investigation of gamified versus traditional training methods in military contracting (Larson et al., 2021). The investigators studied a first-person shooter video game to provide a comparative evaluation of student learning and reaction to the delivery of training against traditional training methods. Although the reported results favored traditional training methods for obtaining performance improvements, their study revealed an interest in using games-based learning among the students tested and provided insights for future gamification studies (Larson et al., 2021).

E. JCORE

Joint Cognitive Operation Research Environment (jCORE) is a framework developed by digital platform development Metateq. Metateq specializes in serious gaming providing specialized products like jCORE (Metateq, n.d.). The modeling and simulation framework within jCORE is used to test and evaluate tactics, techniques, and procedures without being in the real world (Metateq, n.d.). The risk to forces and the financial cost of firing a missile at a ship have the potential to be significantly reduced by using tools provided by jCORE. It supports near-real-time modeling simulation designed to augment decision-making and training. The framework is designed to provide solutions across the armed services and the Department of Defense (Metateq, n.d.).

F. THREAT IDENTIFICATION DECISION ENVIRONMENT

Threat Identification Decision Environment (TIDE) is in development for the U.S. Navy's Information Warfare Training Group. The software features single and multiplayer games for simulating team interaction for engaging threats. It provides a tutorial scenario describing the threats to the ship as well as an introduction to the game's layout, and keyboard hotkeys, and allows the player to see potential threats and actions they can take to identify and combat inbound missiles. Two scenarios and a capstone exercise are also available in the software. The "identify and hard kill" scenario prompts the user to correctly identify missiles based on flight and sensor profiles and apply a hard kill solution before the missile hits the ship and causes damage. The maneuver and soft kill scenario prompt the user to again correctly identify missiles based on flight and sensor profiles but instead of using a hard kill the user must choose between two different solutions and maneuver the ship to properly deploy the solutions. The final capstone scenario combines the other scenarios charging the player to identify and correctly defeat incoming missiles. Players gain points for properly identifying the missile and can pause the game and review the potential missile threats and appropriate responses to each. Supplemental tools and resources like TIDE have been used and developed for increased training capability.

III. METHODOLOGY

A. APPROACH

The research method includes using the game TIDE to evaluate decision-making. Players are to conduct one round of gameplay. Evaluation of gameplay was conducted by observing and documenting the player's choices during the game and the results of the choices made during the scenario. A follow-on survey was presented to the players after the game to address their decision-making process during gameplay. These two data collections appropriately evaluate gameplay in the scenario based on documenting the real-time decisions. Information Warfare Community officers at Naval Postgraduate School were approached to conduct the gameplay.

B. HYPOTHESIS

Hypothesis – Training exposure to the TIDE game increases tactical decision-making for shipboard combat watchstanders.

C. SET UP

The experiments were conducted on a single Windows 11 laptop with the jCORE software containing TIDE loaded onto it. Before the games were played, the screen recording software Camtasia version 2022.4.0 was started and only screen captures were recorded during each student's gameplay. Students from the Naval Postgraduate School each played the game in a private room in the Naval Postgraduate School Dudley-Knox Library. Students had unlimited time to play the game, however, most completed the 12 individual scenarios within 1.5 hours.

D. PROCEDURES

Students were recruited through NPS email. Following scheduling, a specific time slot students were provided a copy of the standard consent form to sign before any part of the experiment occurred. Students were then given a demographic survey and pre-test. The pre-test was used to evaluate previously gained knowledge and training and cue subjects to the training provided in the game. In this experiment training exposure was a 15-minute verbal brief on the threats that were presented to individuals before beginning gameplay. Students were given a printed version of the brief to take notes and use them as needed during gameplay. Following the brief, screen recording was started, and students were instructed to play three rounds of the tutorial scenario. Figure 2 through Figure 6 depict prompts from TIDE as seen by each subject. After each scenario, they were to scroll through the score screen to record their performance for each scenario. Then students were instructed to play three rounds of the Identify and Hard kill scenario, Figure 7 through Figure 9, and subsequently play the Maneuver and Soft kill scenario three times, Figures 10 and 11, then Capstone Exercise three times stopping each time to record the score screen. At the conclusion, the students were given a survey to collect their views of the game and gameplay and post-test with the same questions as the pre-test. Handwritten answers were immediately transferred into digital form and stored on the NPS OneDrive.

Figure 2. Tutorial Incoming Threat Instruction

Figure 3. Tutorial Using a Decoy Instruction

Figure 4. Tutorial Changing Ship's Heading Instruction

Figure 5. Tutorial Toggling Radar Instruction

Figure 6. Tutorial Using a Hard Kill Instruction

Figure 7. Scenario 1 Identify and Hard Kill: Incoming Threat Instruction

Figure 8. Scenario 1 Identify and Hard Kill: Additional Incoming Threat Identification

Figure 9. Scenario 1 Identify and Hard Kill: Incoming Threat Information

Figure 10. Scenario 2 Maneuver and Soft Kill: Inbound Threat Instruction

Figure 11. Scenario 2 Maneuver and Soft Kill: Incoming Threat Decoy Deployment Instruction

E. PARTICIPANTS

Participants included NPS United States Navy students from the Information Warfare, Surface Warfare, and Aviation Communities. These warfare areas qualified individuals for the study due to their exposure to the threats introduced in the game and associated real-life training and shipboard/aircraft experience. Personnel with experience in a combat information center as a tactical watchstander was not required. However, experience and qualifications were documented in the data collection due to experience with identifying threats by air and surface radars. Aviation experience was also considered due to the airborne threats that may be encountered. Participants were not required to have videogame experience.

F. DATA COLLECTION

Data collection was done through the video capture of gameplay as well as handwritten surveys and tests that were immediately transferred to Excel and saved on the NPS OneDrive. Demographic information collected before gameplay included age, gender, time in service, warfare designator, warfare tactics instructor background, ships/aircraft served on, and videogame play. Post-experiment surveys collected information on game mechanics, comparisons to Fleet experience, perceived training effectiveness, willingness to play the game outside of the training environment, and any comments subjects had about the game. Tests covered the responses to three questions about inbound missile threats with active, passive, and infrared seekers. Each question was evaluated for correctness. Answers left blank were recorded as incorrect.

Camtasia is commercial software that was used to record the screen during gameplay. Recording the screen allowed for review of players' decisions for threats. Additionally, the screen recordings of the scores following each scenario were reviewed and scores were transferred to an Excel spreadsheet for further evaluation. No other recordings of personnel video or audio were made.

G. LIMITATIONS

Limitations of the experiment include equipment, software, and personnel. There was only one machine in use for this experiment that the subjects used. Multiple machines were not required, but would have allowed multiple experiments to be run at once. On one occasion the machine crashed due to a battery fault, and the time for repair and recovery resulted in the loss of gameplay for one experiment subject. This did not have a major impact on the study as it only happened once.

The software used is a commercial product in demo mode. Not all features were available during the time of the experiment to include jCORE player profiles to save player performance and scores and multiplayer games. While this was not used for the experiment future studies may benefit from this capability.

Personnel limitations include the NPS student population recruited for this experiment. The game is geared toward sailors however only officers played the game in this round of experimentation. The watch stations stood by officers and enlisted sailors in combat are different in the Fleet and the specific knowledge and skill transfer would need further study. However, students involved in this training stood or have the potential to stand at different watch stations where this skill transfer would benefit the combat watch team.

IV. RESULTS

Two types of data were collected – subjective data from both demographic and post-scenario surveys and objective data from the games. All data were entered into Microsoft Excel and the statistics program JMP was used for analyzing data.

A. SUBJECTIVE DATA

Subjects filled out three surveys generic demographic, a pre-test evaluation of threat response performance, and a post-test for observations and opinions after completing the experiment. Demographic data collected and included: age, gender, years in service, warfare designator, watch standing, type of aircraft or ship served on, videogame play, and type of videogame platforms users played on.

Graphs containing the data distribution are depicted below. A graph for the subject's gender is in Figure 12. The average age of participants was 31 years. The average years of service among the 31 participants was 7 years. A graph representing the subjects' warfare designator is found in Figure 13. A graph representing the subjects tactical watchstanding experience shown in Figure 14 followed by a graphical breakdown of individual watch station experience in Figure 15. Subjects' platform experience by ship type and aircraft is shown in Figure 16. Multiple subjects had experience with several watchstations. A graph of the subject's video game play is in Figure 17. Of subjects with videogame experience, they were further asked to list the type of platform used to play displayed in Figure 18.

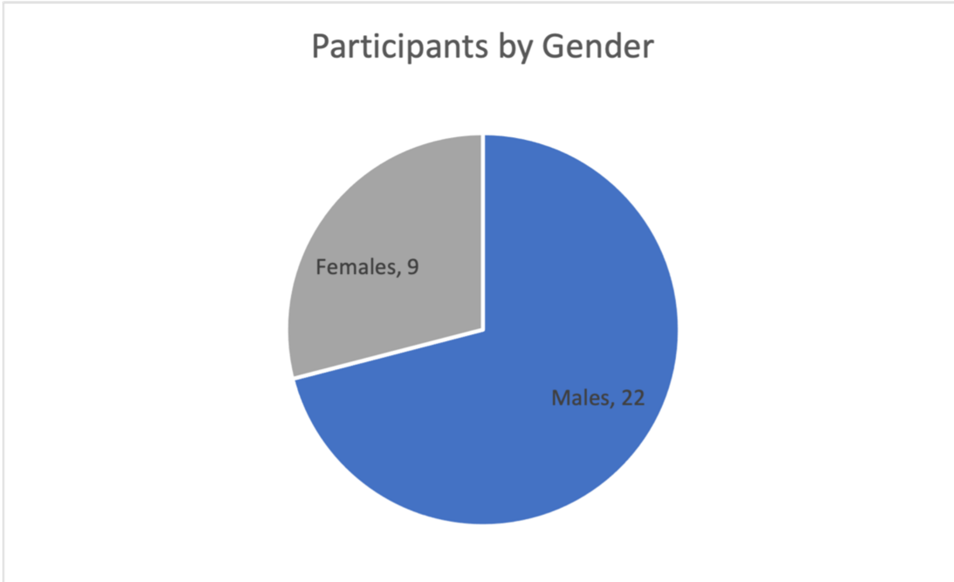

Figure 12. Participants By Gender

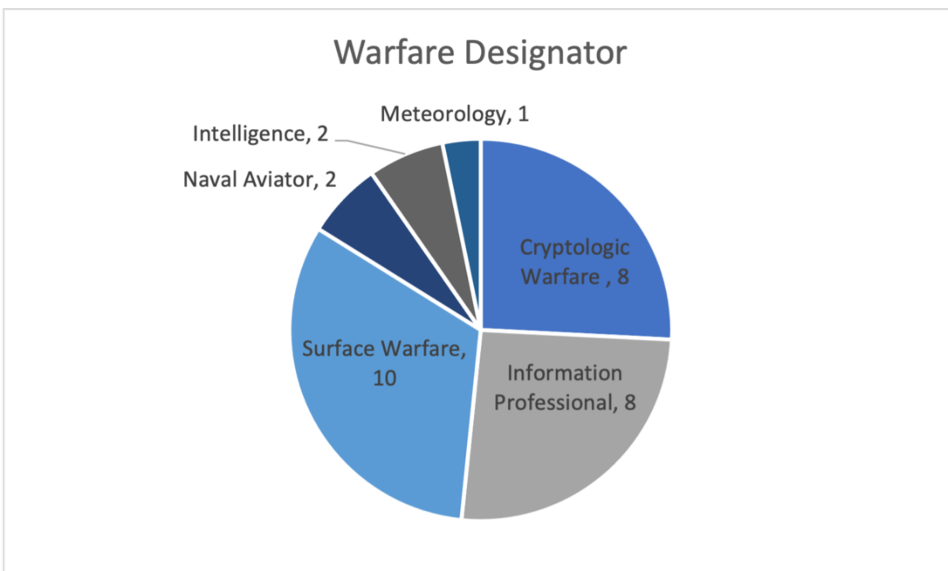

Figure 13. Warfare Designator

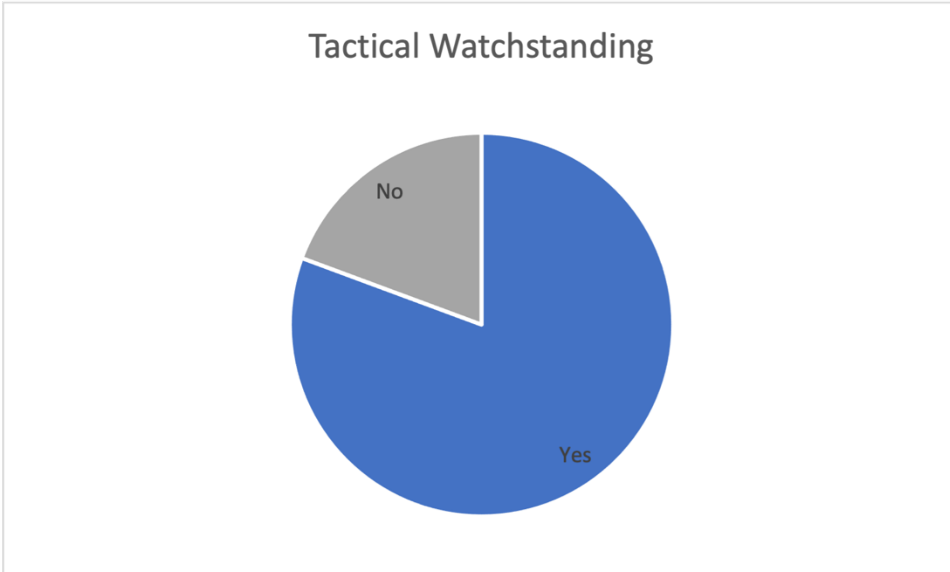

Figure 14. Tactical Watchstanding Experience

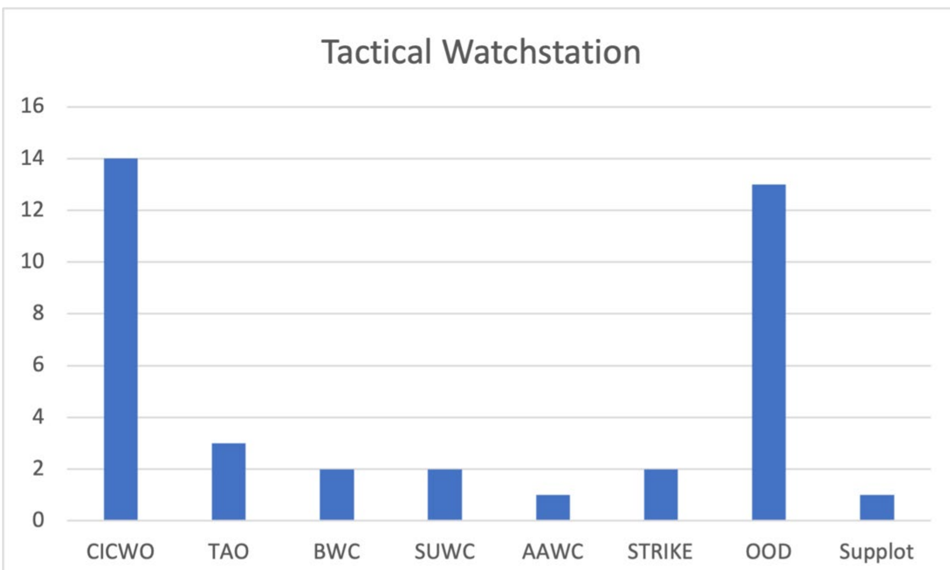

Figure 15. Tactical Watchstations

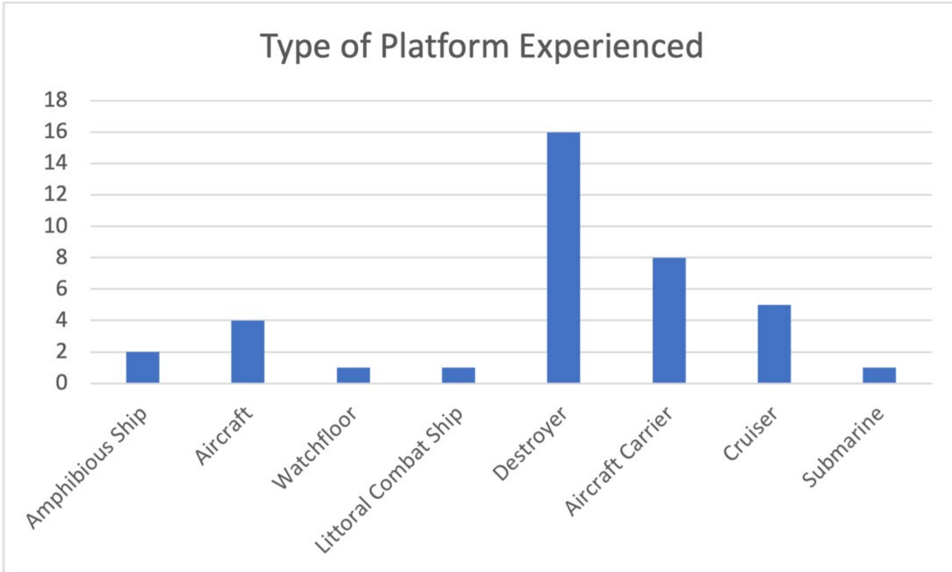

Figure 16. Type of Platform Served On

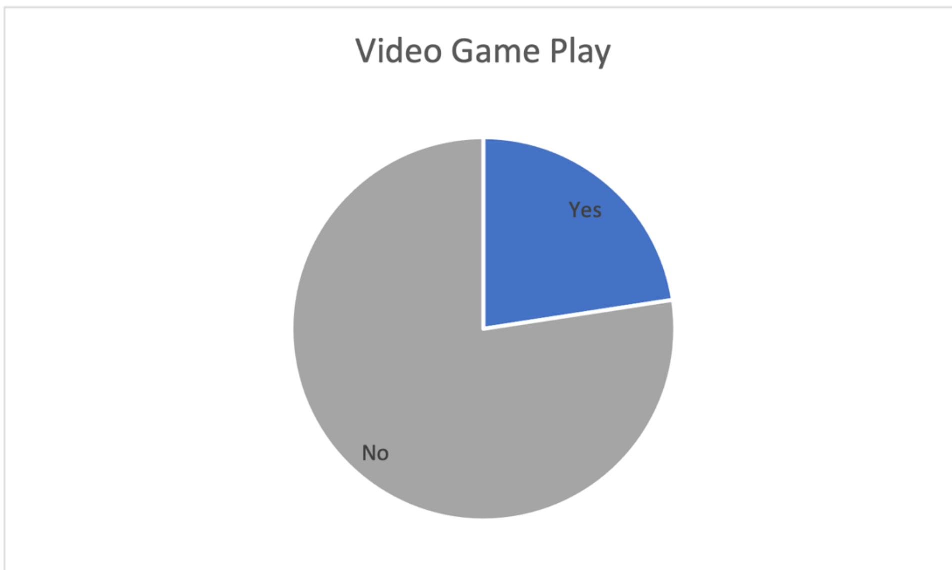

Figure 17. Videogame Play

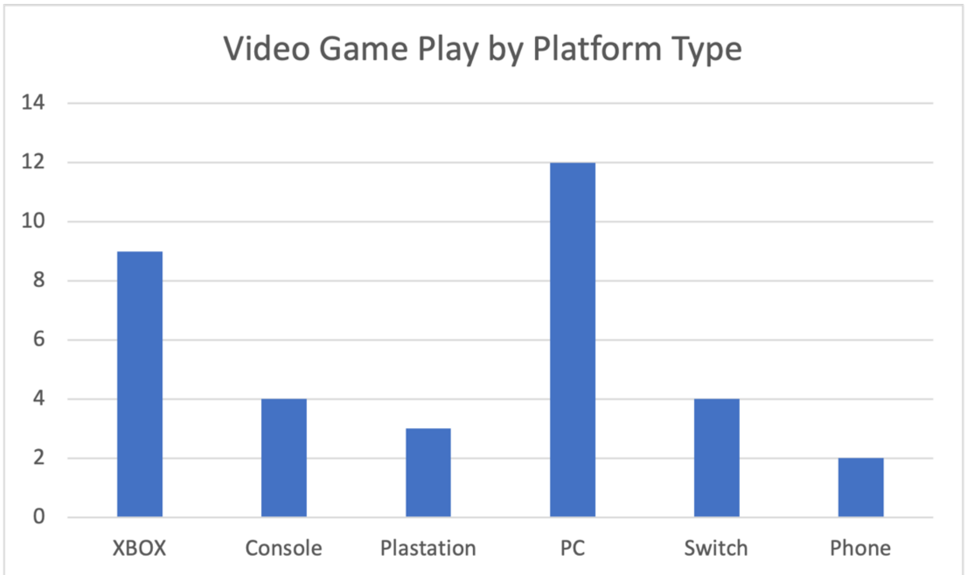

Figure 18. Video Game Play by Platform Type

The pre-test asked the users how they would respond to inbound missile threats. For active seekers, the correct answer was to execute a hard kill, launch a decoy, or launch chaff. For Passive seekers the correct answer was to hard kill the threat with missiles. For infrared seekers, the correct answer was to launch flares. Any other answer was marked as incorrect. While some answers included viable responses to inbound threats the above pertained specifically to the TIDE scenario briefing. Figure 19 contains the subjects' performance on the pre-test.

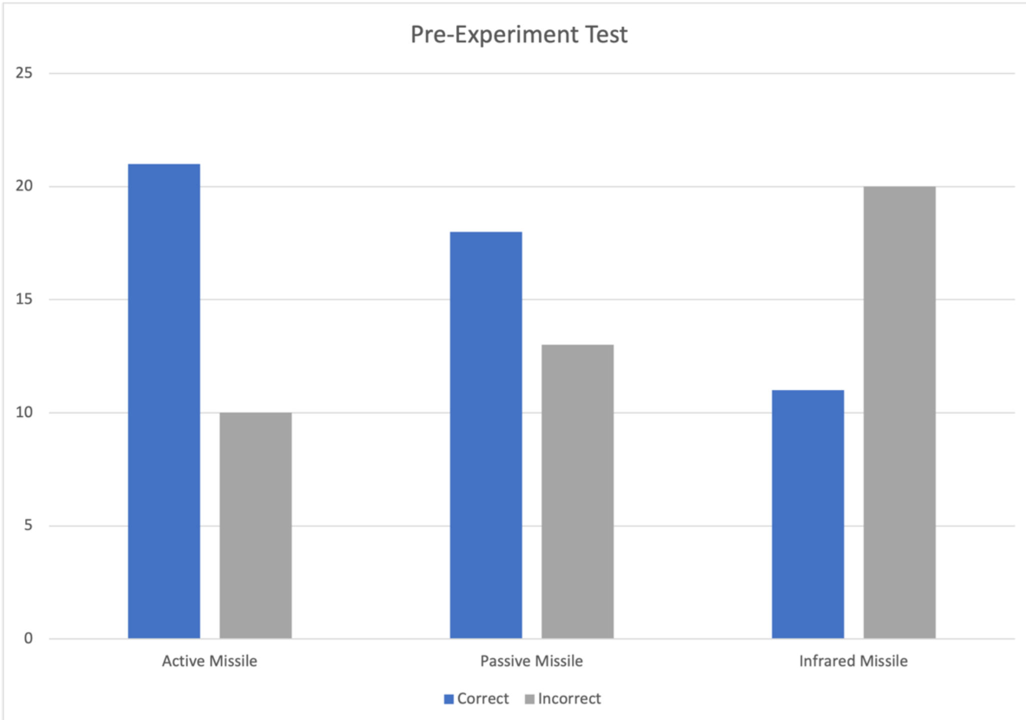

Figure 19. Pre-Experiment Test Results

The post-test experiment survey evaluated how subjects felt after playing the game. Subjects were asked about the difficulty of instructions, unrealistic components of gameplay, comparison to Fleet experience and shipboard scenarios, how effective they thought the game was, and how often they would play if this was available in the Fleet. A majority of the participants thought the training was effective as depicted in Figure 20.

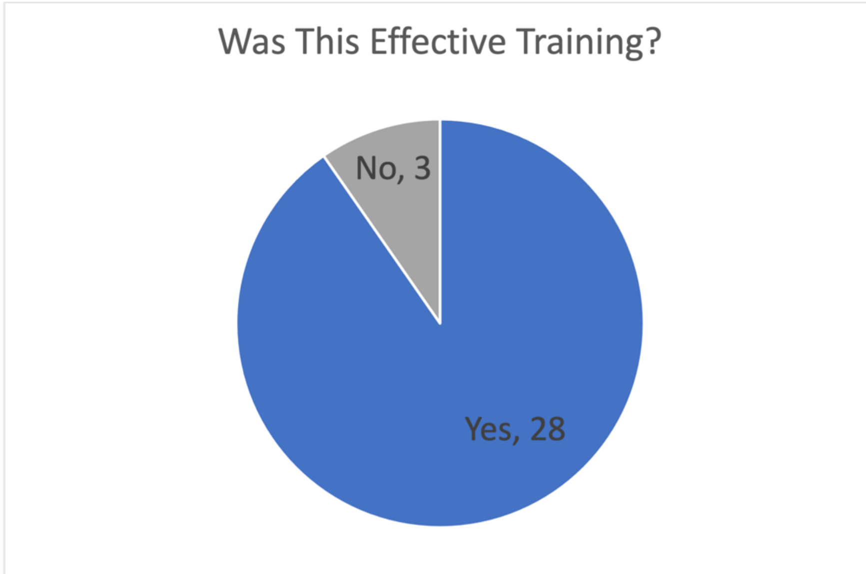

Figure 20. Post Survey Question Results on Effective Training

B. OBJECTIVE DATA

In this experiment evaluating an increase in performance is measured by individual scores based on proper identification of inbound missile threats. Performance data was collected for each iteration of gameplay. The tutorial and three scenarios were evaluated separately. Each subject played the tutorial and each of the three scenarios three times. The tutorial was used as a baseline to get the subject familiar with the display, understand the menu options and buttons available for them to use, as well as the initial identification of threats. Performance factors were evaluated on a 3-point maximum score which was calculated by the number of correctly identified missiles in the tutorial. The maximum score was assigned based on the subject correctly identifying three missiles. Figure 21 shows the scores for identifying missiles properly during the tutorial. Subjects could score negatively if they incorrectly identified the inbound missiles.

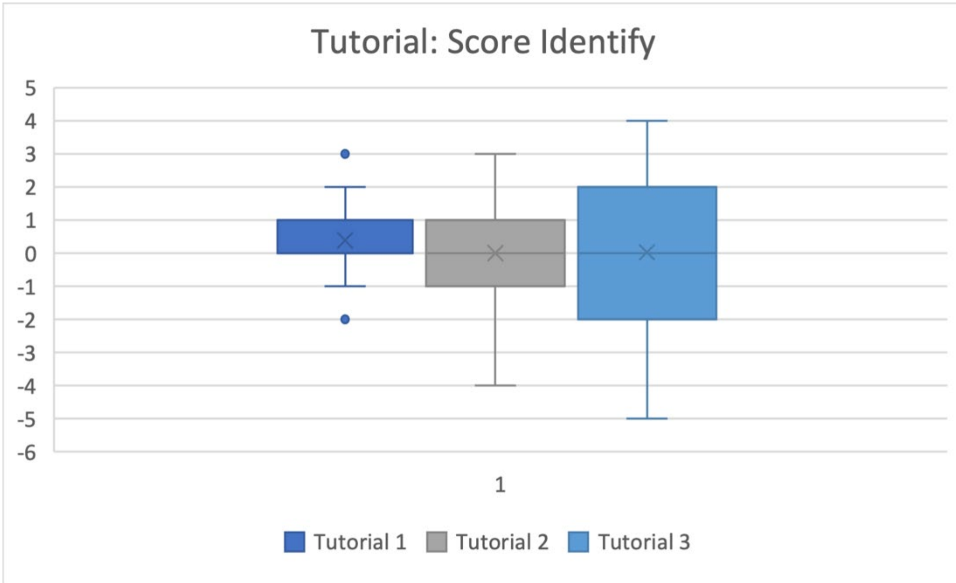

Figure 21. Tutorial 1 by Missile Identification Score

Following the tutorial, subjects played Scenario 1 to identify and execute a hard kill on the threat. The scenario was graded on a six-point maximum scale. Points were rewarded for subjects correctly identifying missiles. Other data collected for scenario 1 included missiles detected by the subject, missile use, and effective actions. Figure 22 shows the scores of missile identification score for each iteration of gameplay. Figure 23 shows the overall score of individuals for each iteration of gameplay. Subjects could score negatively if they incorrectly identified the inbound missiles. The data in Figure 22 and Figure 23 indicate a positive trend of increasing scores from the first play of scenario 1 to the third. The outlier -4 in the score identity for Scenario 1.1 and Scenario 1.2 are from two different subjects during gameplay. More players were able to score between two and four points by the third play of scenario 1 indicating increased performance during the gameplay.

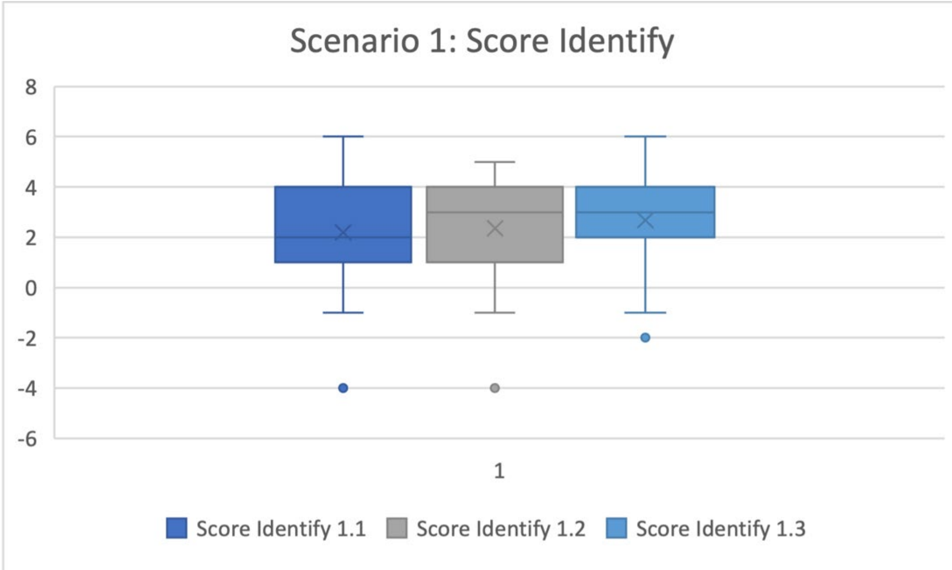

Figure 22. Scenario 1 by Missile Identification Score

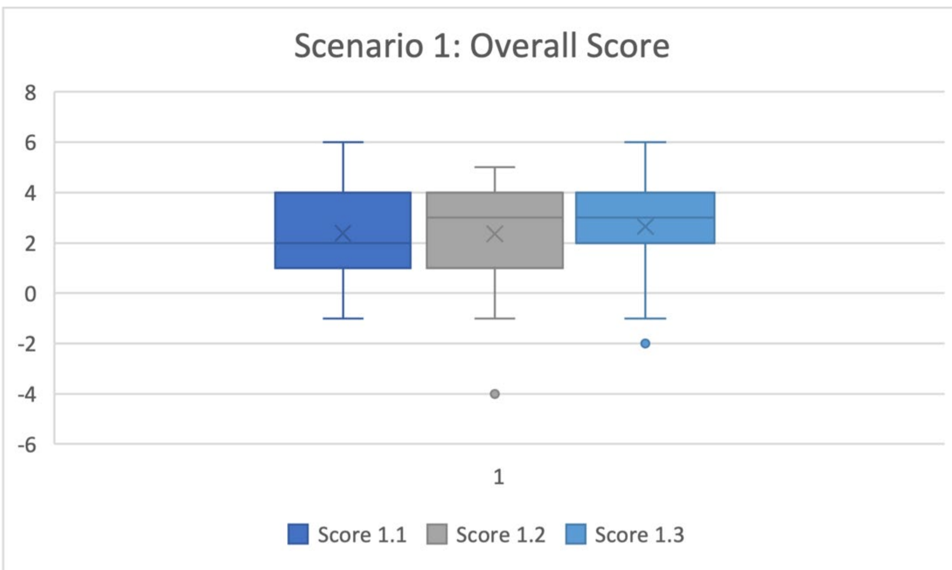

Figure 23. Scenario 1 by Overall Score

Scenario 2 required the subject to correctly identify the inbound missile, maneuver the ship using the available in-game controls, and launch the proper decoy to effectively respond to the inbound threat. The scenario was graded on a 10-point maximum for identifying the missile and taking proper action against it. Figure 24 shows the score identifies for each iteration of gameplay.

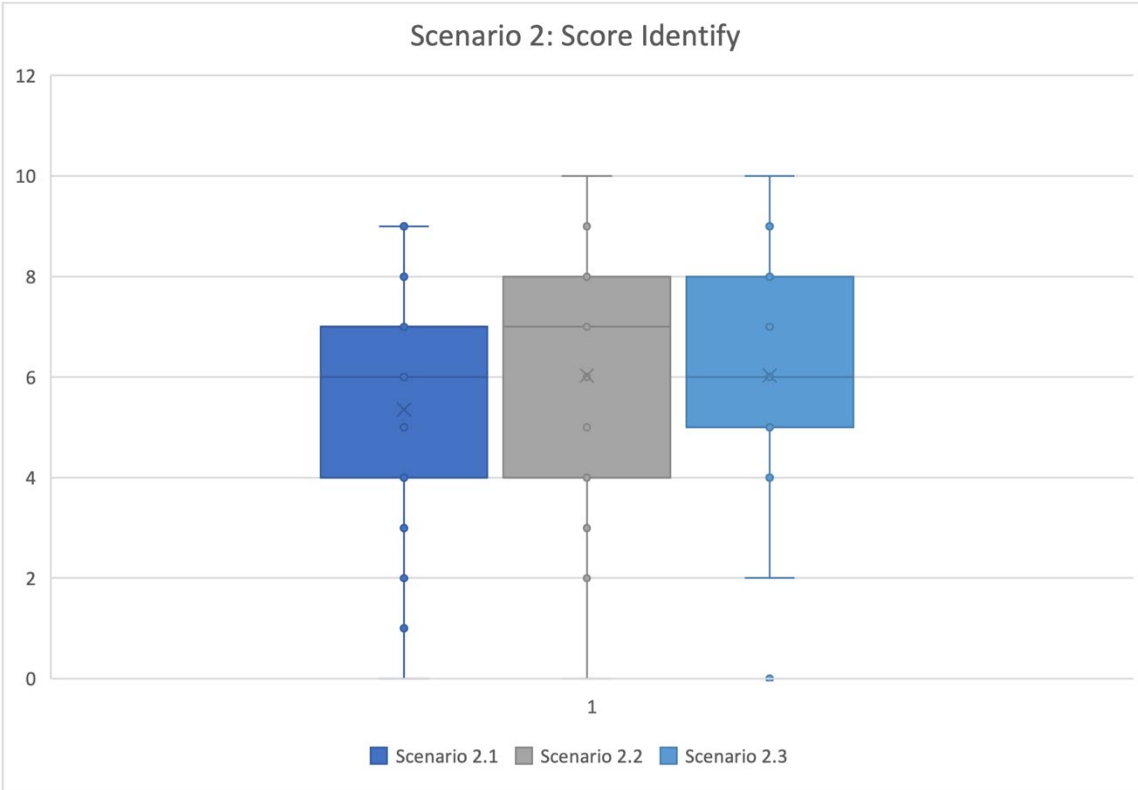

Figure 24. Scenario 2 Missile Identification Score

Scenario 3 is the Capstone scenario in TIDE. It tests the user on their ability to properly detect, identify, and engage with the inbound threat. In this experiment tactical decisions are defined as identifying the threat and reacting accordingly to defeat or deter an inbound missile threat. The score was evaluated based on a 20-point scale and included factors of missile detection, score identification, and effective actions broken down by appropriate use for each soft kill, hard kill, or decoy if the user chose the proper response. Figure 25 depicts the score identified for each gameplay. Figure 26 shows the overall scores for each gameplay.

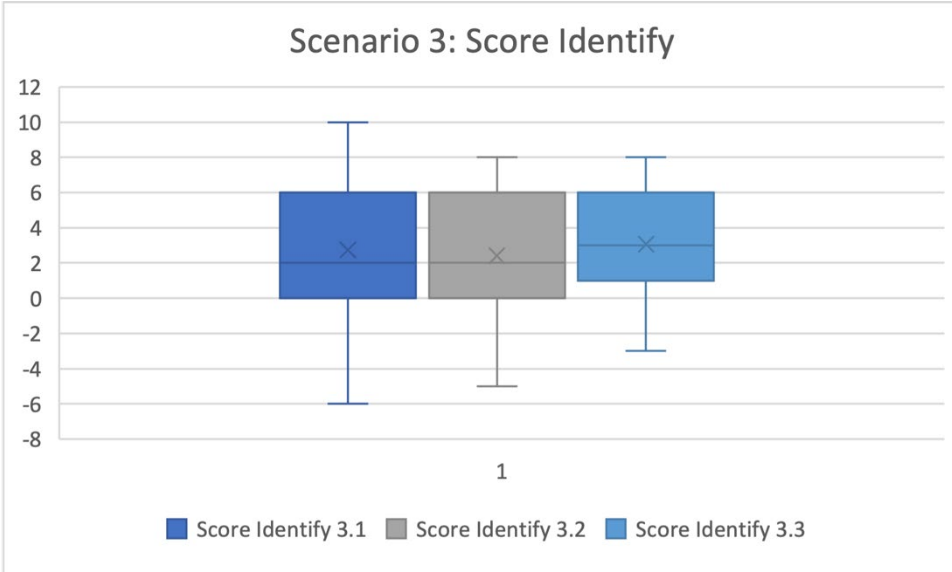

Figure 25. Scenario 3 by Missile Identification Score

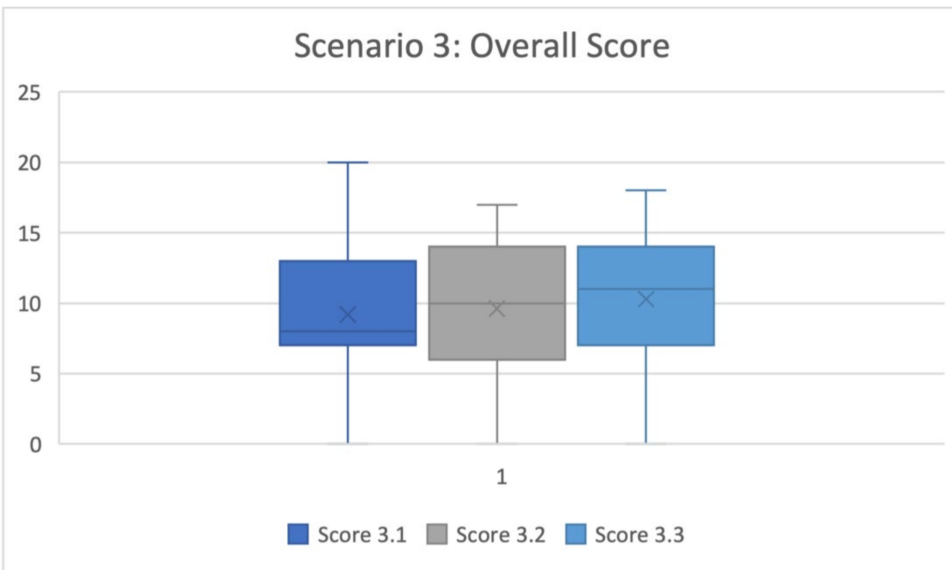

Figure 26. Scenario 3 by Overall Score

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V. DISCUSSION

The experiment tested subjects with three to twenty-two years in service with varying background designators and experience on ships and aircraft. Each relied on previous experience and exposure to answer the pre-test questions. Some subjects answered with multiple correct answers that would be included in TTPs specific to addressing the threat immediately and follow-on actions for a given platform.

A. DATA DISCUSSION

The data shows trends of increasing performance throughout gameplay supporting the hypothesis that training exposure using TIDE increases tactical decision-making. Users were given feedback by TIDE in the form of scores following each scenario. Figure 27 shows all performance data for all scenarios and all participants with associated trend lines. Twenty-three of thirty-one participants show a positive performance trend. For the tutorial, the data in Figure 21 shows an increase in the range of scores indicating that individuals performed poorly. The tutorial is intended to teach the user the keyboard strokes and mouse clicks and movements required to interact with the game. Data shows that users on average from the first to third scenario deployed more missiles and decoys in the game to counter threats. Additionally, the average number of effective actions used increased. The effective actions are listed in Table 1. This indicates that users while not performing as well with identifying threats, were more likely to try to use the available tools in the game to defeat the inbound missile.

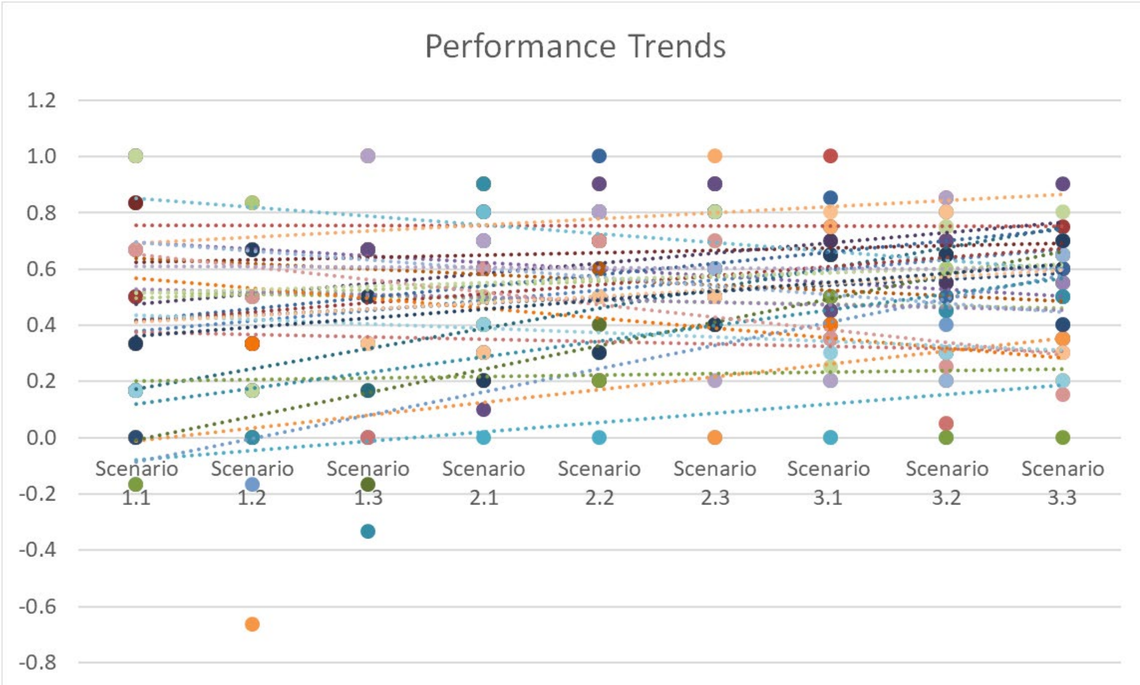

Figure 27. Performance Trends of Subjects

Table 1. Tutorial Effective Actions Used

	Effective Actions Average	Missiles Used	Decoys Used	Average Effective Actions	Average Missiles Used	Average Decoys Used
Tutorial 1	28	43	2	0.87	1.34	0.06
Tutorial 2	62	62	4	1.94	2.07	0.12
Tutorial 3	62	66	8	1.94	2.13	0.25

Scenario 1 included fewer prompts than the tutorial for users to follow. Table 2 shows the average missile use and effective actions and the total missiles used and total effective actions. From Scenario 1.1 to Scenario 1.3 subjects used more missiles to defeat incoming threats. This indicates that the users of the hard kill scenario understood that launching more missiles at a threat would protect the ship. In this experiment, this is an indicator of increased performance using the TIDE game.

Table 2. Scenario 1 Average and Total Missile Use and Effective Actions

	Missile Use	Effective Actions	Total Missiles	Total Effective Actions
Scenario 1.1	4.29	3.9	133	121
Scenario 1.2	4.58	4.4	137	127
Scenario 1.3	4.9	5.8	147	146

Scenario 2 similarly included fewer prompts to the user than the number of prompts in Scenario 1. The data collected for scenario 2 was based on the subject's ability to maneuver the ship and use soft kills to deter threats from the ship. Figure 24 shows an overall increase in performance based on the score identify for Scenario 2 concentrating subjects' scores between 5 and 8 points. An interesting data comparison is between the score and actions over time. While on average the actions over time in each scenario increased, the actions over time are not an indicator of higher scores during gameplay shown in Table 3. A comparison of these data points for Scenario 2 is in Table 4 with an asterisk (*) indicating low overall scores with actions over time higher than the average for the scenario. A note regarding the null variables is needed: these are listed as null due to faults in the data collection, which was a result of failure of the recording software.

Table 3. Scenario 2 Average Actions over Time

	Actions Over Time
Scenario 2.1	18.533
Scenario 2.2	20.466
Scenario 2.3	21

Table 4. Scenario 2 Scores and Actions over Time

Subject	Score 2.1	Actions Over Time 2.1	Score 2.2	Actions Over Time 2.2	Score 2.3	Actions Over Time 2.3
1	8	19	8	27	9	26
2	7	14	7	14	5	14
3	9	16	8	20	9	17
4	4	14	7	20	9	17
5	NULL	NULL	NULL	NULL	NULL	NULL
6	6	13	10	14	NULL	NULL
7	7	13	8	19	8	19
8	8	30	8	30	6	30
9	3	23	4	24	6	27
10	9	19	7	19	8	20
11	6	12	6	15	6	13
12	2	24*	6	24	8	23
13	6	26	2	29*	5	29*
14	4	14	7	14	4	20*
15	4	17	8	19	7	19
16	4	19	5	23*	6	19
17	8	25	8	20	8	20
18	9	23	9	25	10	35
19	3	23*	10	24	8	24
20	6	13	2	13	5	13
21	4	11	2	18*	4	25
22	1	16	9	25	9	26
23	9	24	7	22	5	19
24	5	16	7	14	5	14
25	7	21	8	17	6	20
26	6	23	7	19	7	21
27	5	23*	3	23*	8	20
28	7	17	8	19	2	18
29	4	10	5	13	5	15
30	3	20*	5	31*	5	27
31	2	18*	3	20*	4	19

Scenario 3 was the capstone event. It required both that the subject understand threat identification and that they react appropriately. The scores for identifying and the overall score increased from scenario 3.1 to scenario 3.3 indicating users increased performance in making decisions by playing the game. Further analysis of the effective actions including missiles and decoy launches shows that subjects made decisions to launch the appropriate countermeasure to defeat the threat. Table 5 shows the totals of effective hard kills and effective decoys used during each Scenario 3 gameplay.

Table 5. Scenario 3 Total Soft Kills and Hard Kills

	Total Soft Kill Use	Total Missile Use	Total Decoys Launched	Total Chaff Launched	Total Flares Launched	Effective Hard Kills	Effective Decoy
Scenario 3.1	183	110	8	0	0	102	8
Scenario 3.2	161	131	11	1	1	126	11
Scenario 3.3	162	152	11	1	0	147	11

B. TRAINING IN THE FLEET

Enlisted sailors and officers alike could benefit from exposure to identifying and responding to threats in a low-threat situation. The motivation in the game is to keep the ship from being hit by missiles to score more points. On a ship identifying and responding to a missile is a matter of life and death. Watchstanders can have an automatic response to a threat. Thus, they will defend the ship and prevent casualties. TIDE provides a low-risk environment with unclassified parameters that users could play on a standalone machine while learning to fight the ship. The recognition and response to threats is a learned connection between stimulus and action. It can be used when a sailor is learning the full spectrum of procedures of their watch station.

Additional uses of TIDE could be incorporating the game into the training of Combat Information Center Watch Officers and Tactical Action Officers. TIDE would be beneficial to officers or senior enlisted sailors when they are first beginning to learn threats and respond to them. This would not only benefit the individual but the entire watch team as more than one person can recognize the incoming threat. For personnel transitioning from shore duty to sea duty, TIDE could provide refresher training to prime their understanding of threats.

C. A MOVEMENT TO DIGITAL TRAINING

Digital training meets some of the Navy's needs for RLL. TIDE is tailored towards combat watchstander training and decision-making by gamifying threat identification.

Other digital training tools could be considered and used across the Fleet for training individual watchstanders. TIDE also can integrate multiple users dividing the effort of identifying and responding to threats. Training needs must be evaluated to ensure the effectiveness of the tool. Potential integration of TIDE into new officer training or later in the officer's career during shore-to-sea transition is an area for further consideration.

D. SURVEY RESPONSES

The post-experiment survey responses identified areas of the game for enhancement. One response included adding a highlighted box around the controls and functionality buttons during the tutorial to direct the user to where their controls were located. Another response included adding a keyboard hotkey for "execute" instead of requiring multiple clicks to deploy a counterattack. One functionality feature that needs to be addressed by the game manufacturer is indicating when a user has turned the ship's radars off or on in response to an inbound missile threat. There is no visible change on the screen that indicates to the user the status of their radars. When asked if the subjects would play the game on their own, the majority of users said they would not play it on their own time; however, if they were on deployment or sea duty they would spend free time playing the game.

VI. CONCLUSION

A. RECOMMENDATIONS

The experiment was successful. Twenty-eight of thirty-one subjects deemed TIDE effective training. Further investigation of the tool with enlisted sailors on ships is required to evaluate the full potential of TIDE. Integrating TIDE as an additional training tool would help meet Fleet requirements for watch standing, combat training scenarios, and training at initial rating schools. Evaluating TIDE compared to a ship training scenario during strike group operations would also be beneficial to developing TIDE to meet fleet requirements.

To track individuals over time, JCORE can create individual user profiles. These profiles save user data and provide a method for data collection and evaluation. Using Camtasia to record information was a viable solution and worked for the experiments for this thesis. However, there were cases where users accidentally stopped the recordings, recordings cut off portions of the screen, and files were too large to transfer to the NPS cloud during collection sessions and took hours to upload when connected to the NPS wireless network. Over time profiles for users could be used to evaluate performance when playing multiple iterations of the game with gaps of time in between each session.

Player feedback for training within the game would be a feature to include in TIDE in addition to the scores after each scenario. For example, within the identify and hard kill scenario, if a player incorrectly identifies a missile the user would receive immediate feedback on a missile they missed. For example, feedback would include elements of identifying the missile such as the altitude, speed, or frequency data. Similar feedback could be integrated into the tutorial or other scenarios.

TIDE has a multi-player gaming functionality. This multiplayer game could be used to train a watch team and would focus on different elements of training. Communication skills and role requirements of individuals would become the focus of the game, and division of effort would drive each scenario. This would more closely emulate a shipboard environment integrating sailors into a watch team before being placed in a Fleet scenario.

For proper evaluation of TIDE it is necessary for it to be tested in the Fleet. This experiment was tested on individuals with Fleet experience on different platforms and with different warfare backgrounds. For the incorporation of TIDE into information warfare training, sailors that perform the functions of the watch stations in combat would need to be evaluated.

B. FUTURE WORK

Develop specific scenarios for area-based deployments. TIDE contains generic missile threats that it trains users to react to. Development of specific adversary threats found in the theater that a ship or strike group is deploying to would tailor training for individual units during the training cycle. This type of training would prepare individuals for TTPs a ship would undertake in a real-life threat scenario and train them to react quickly to an understood threat within the capabilities of a ship. Information contained within the scenarios would increase the classification requiring both developers, systems, and users to be cleared to interact with the game, however, would not be an insurmountable task to transition from unclassified to classified training tool.

Integrate the entire combat team. Cooperative multiplayer training is an area of interest due to the different roles on a watch team. The identification and decision-making load would be spread across multiple sailors to combat inbound threats. Roles defined by training requirements would have to be defined within the game set up and rules to evaluate the gameplay would need to be established before conducting multiplayer training.

Full evaluation of the training curriculum and requirements for Fleet integration of digital training is a prerequisite for going forward with TIDE. Requirements from assessing coursework before sailors arrive at a ship, onboard training requirements, and live training would identify areas of improvement that TIDE could address.

APPENDIX A. PRE-EXPERIMENT DEMOGRAPHIC SURVEY

Pre-Experiment Survey

Subject Number:

Demographic Info

Age:

Gender:

Time in the Navy:

Designator:

Warfare Tactics Instructor background?

Ship types/aircraft served on?

Videogame play? What type of platform (computer, game console, etc.)?

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APPENDIX B. PRE-EXPERIMENT TEST

Pre-Game Test

Subject #

How would you respond to an inbound missile with an active seeker?

How would you respond to an inbound missile with a passive seeker?

How would you respond to an inbound missile with an infrared seeker?

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APPENDIX C. POST-EXPERIMENT SURVEY

Post Experiment Survey

Subject Number:

Difficulty understanding the instructions/components of the game

Were there unrealistic scenario components that changed the decisions made in gameplay?

What improvements to the scenario are suggested for enhanced gameplay?

How does this compare to Fleet experience?

Would you make the same decisions if in a shipboard scenario?

Did you think this was effective training?

How much would you play the game on your own?

Did you find a problem with the interface?

Additional comments:

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