NAVAL POSTGRADUATE SCHOOL

MONTEREY, CALIFORNIA

THESIS

SHIP HANDLING TRAINER USING PERSONAL DEVICES

by

Joshua J. Stewart

December 2018

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

Research for this thesis was performed at the MOVES Institute.

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REPORT DOCUMENTATION PAGE			*Form Approved OMB No. 0704-0188*
Public reporting burden for this collection of information is estimated to average 1 hour per response, including the time for reviewing instruction, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington, VA 22202-4302, and to the Office of Management and Budget, Paperwork Reduction Project (0704-0188) Washington, DC 20503.			
1. AGENCY USE ONLY ***(Leave blank)***	**2. REPORT DATE** December 2018	**3. REPORT TYPE AND DATES COVERED** Master's thesis	
4. TITLE AND SUBTITLE SHIP HANDLING TRAINER USING PERSONAL DEVICES			**5. FUNDING NUMBERS**
6. AUTHOR(S) Joshua J. Stewart			
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) Naval Postgraduate School Monterey, CA 93943-5000			**8. PERFORMING ORGANIZATION REPORT NUMBER**
9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES) N/A			**10. SPONSORING / MONITORING AGENCY REPORT NUMBER**
11. SUPPLEMENTARY NOTES The views expressed in this thesis are those of the author and do not reflect the official policy or position of the Department of Defense or the U.S. Government.			
12a. DISTRIBUTION / AVAILABILITY STATEMENT Approved for public release. Distribution is unlimited.			**12b. DISTRIBUTION CODE** A

13. ABSTRACT (maximum 200 words)

A fundamental skill that must be developed by all Surface Warfare Officers (SWOs) is shiphandling. Currently, the only ways for a junior SWO to practice shiphandling are through the Conning Officer Virtual Environment (COVE) training system at Basic Division Officers Course (BDOC), the Navigation, Seamanship, and Ship-Handling (NSS) trainers at fleet concentration areas, and driving their actual ship. In order to increase opportunities to practice this critical skill, this thesis investigated the effectiveness of a tablet-based shiphandling training application. A prototype tablet training application was developed for this study. The training application includes a user-controllable virtual ship in a pier-landing scenario, with optional wind and current that shows the resultant forces on the ship. For the effectiveness study, the tablet group practiced pier landings using the tablet application for twenty minutes before executing a similar scenario in COVE graded by a BDOC instructor using BDOC evaluation methods. The control group conducted the COVE scenario without using the application. The study concludes that the tablet group performed better than the control group, but not at a statistically significant level. More testing will be needed to establish that the application does indeed improve performance.

14. SUBJECT TERMS training, surface, surface warfare, shiphandling, ship handling, mobile, mobile device, mobile device training			**15. NUMBER OF PAGES** 111
			16. PRICE CODE
17. SECURITY CLASSIFICATION OF REPORT Unclassified	**18. SECURITY CLASSIFICATION OF THIS PAGE** Unclassified	**19. SECURITY CLASSIFICATION OF ABSTRACT** Unclassified	**20. LIMITATION OF ABSTRACT** UU

NSN 7540-01-280-5500

Standard Form 298 (Rev. 2-89)
Prescribed by ANSI Std. 239-18

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SHIP HANDLING TRAINER USING PERSONAL DEVICES

Joshua J. Stewart
Lieutenant, United States Navy
BS, U.S. Naval Academy, 2011

Submitted in partial fulfillment of the
requirements for the degree of

MASTER OF SCIENCE IN COMPUTER SCIENCE

from the

NAVAL POSTGRADUATE SCHOOL
December 2018

Approved by: Rudolph P. Darken
Advisor

Perry L. McDowell
Co-Advisor

Peter J. Denning
Chair, Department of Computer Science

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ABSTRACT

A fundamental skill that must be developed by all Surface Warfare Officers (SWOs) is shiphandling. Currently, the only ways for a junior SWO to practice shiphandling are through the Conning Officer Virtual Environment (COVE) training system at Basic Division Officers Course (BDOC), the Navigation, Seamanship, and Ship-Handling (NSS) trainers at fleet concentration areas, and driving their actual ship. In order to increase opportunities to practice this critical skill, this thesis investigated the effectiveness of a tablet-based shiphandling training application. A prototype tablet training application was developed for this study. The training application includes a user-controllable virtual ship in a pier-landing scenario, with optional wind and current that shows the resultant forces on the ship. For the effectiveness study, the tablet group practiced pier landings using the tablet application for twenty minutes before executing a similar scenario in COVE graded by a BDOC instructor using BDOC evaluation methods. The control group conducted the COVE scenario without using the application. The study concludes that the tablet group performed better than the control group, but not at a statistically significant level. More testing will be needed to establish that the application does indeed improve performance.

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LIST OF ACRONYMS AND ABBREVIATIONS

ADOC	Advanced division officer course
BDOC	Basic division officer course
BRM	Bridge resource management
BSH	Basic shiphandling course
CICWO	Combat information center watch officer
CO	Commanding officer
COLREGS	International regulations for preventing collisions at sea
CONN	Conning officer
COVE	Conning officer virtual environment
CPP	Controllable Pitch Propeller
DDG	Guided missile destroyer
DH	Department head
FCA	Fleet concentration area
FMB	Full mission bridge
HMD	Head mounted display
I/ITSEC	Interservice/Industry Training, Simulation, and Education Conference
JO	Junior officer
JOOD	Junior officer of the deck
MOB	Man overboard
MOBOARDS	Maneuvering Boards
MOVES	Modeling, virtual environments, and simulation
NTRCS	Navy non-resident training courses
NSST	Navigation, Seamanship, and Shiphandling Trainer
PC	Personal computer
OCS	Officer candidate school
OIC	Officer in charge
OOD	Officer of the deck
RoR	Rules of the road

ROTC	Reserve officer training corps
SET	Special evolutions training
STA-21	Seaman to admiral-21 program
SWO	Surface warfare officer
SWOS	Surface warfare officer school
TYCOM	Type commander
UI	User interface
UNREP	Underway replenishment
USNA	United States Naval Academy
VR	Virtual reality
YP	Yard patrol craft

ACKNOWLEDGEMENTS

The author would like to thank Professor Perry McDowell and Dr Rudy Darken of the MOVES institute. Thank you both for your guidance and keeping me on track throughout the writing of this thesis. You were both indispensable. Thank you.

I would also like to thank the staff of the Basic Division Officer Course in San Diego, CA, for making time for me and enthusiastically supporting this thesis and my research. This research depended upon their support and would not have been possible without them. Thank you.

I would also like to thank all of the students and instructors at BDOC who participated in the study and provided feedback. It was invaluable to this research and for future work in this area. Thank you.

Finally, I want to thank my beautiful wife, Michelle. Thank you for supporting me throughout all of this and putting up with the busy schedule, research trips, and most importantly, listening when I needed someone to talk to. I love you.

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I. INTRODUCTION

A. RESEARCH PROBLEM AND MOTIVATION

1. Importance of Conning for the Navy

Having the conn of a warship is the core of the surface warfare Navy. It is the first thing young surface warfare officers (SWOs) are directed to learn as a professional, and it remains a critical part of being a SWO for the rest of their careers, from a first tour division officer to the commanding officer (CO): "Shiphandling in one of the key measures of a naval officer" (Barber, 2005). Conning has been and will always be a cornerstone of the surface Navy.

a. Definition of Conning

That begs the question, what exactly is conning? What does it mean and what does it entail? Having the "conn" means that officer is in direct control of the ship's controllable forces, those being the engines, rudder, tugs, lines, and anchors. The conning officer will carry out the orders of the officer of the deck (OOD) and the CO, but remains in sole command of the helmsman. To control these forces, the conning officer uses a series of verbal standard commands to other bridge personnel, and all officers must master the standard commands before they are ready to take the conn. These standard commands remove ambiguity and are critical because when giving orders to control a massive warship in tight formation, conducting an underway replenishment (UNREP), or taking the ship pier side, there is no room for miscommunication or ambiguity.

b. Cannot Fight a Ship if Cannot Get it Safely to Warzone

It is of great importance that every SWO, from the most junior ensign onboard to the CO be a capable mariner. A naval vessel's value is in its ability to maneuver into the battlespace, wherever that may be. In order to get to the battlespace safely and quickly, the ship must be able to get underway rapidly in any condition from any port in the world. Today there is a lot of reliance on harbor pilots, even overseas. Even with this it is critical that the SWOs onboard are able to handle the ship in all conditions no matter what.

Warships are most valuable when out to sea ensuring freedom of navigation, projecting power, and supporting American interests, and they cannot do this mission set if the officers onboard cannot safely get the ship underway and to the fight.

c. Description of What a Conning Officer Actually Does

The conn is a watch station on the bridge of a warships. Every SWO will qualify as a conning officer early in their career, and it is usually the first official watch they will stand. The conning officer will stand their watch and will work directly for the OOD. The OOD is the CO's representative and is responsible for overall operations of the ship and safe navigation. There also may be a junior officer of the deck (JOOD), but this watchstander assists the OOD in executing the other duties on the bridge, which could be anything from working maneuvering boards (moboards), talking with other naval vessels or commercial vessels over the radio, or whatever else is required.

The conning officer's sole job is to drive the ship, and they are not expected to be tasked with anything else [while they have the conn]. They will take direction directly from the OOD regarding the overall maneuvering plan, but retain the sole authority to give orders to the Sailor or Sailors controlling the helm (rudder) and lee helm (engines). There are a multitude of factors that the conn must keep track of and account for before or during any order, so it is critical that he/she be allowed to focus solely upon driving the ship.

2. Difficulty of Conning

Conning a ship is no easy task, and junior SWOs are expected to learn how to do it quickly after checking onto their first ship. First, they need to understand and be able to use standard commands without having to think about it: "Conning a ship requires autocratic leadership: crisp, sharp, clear, precise, and unambiguous orders. That is why we use standard commands" (Barber, 2005). After that, the conn must understand the physical characteristics of the ship (Barber, 2005). They must understand how all of these different forces affect each other and know how they affect the overall handling of the ship. After these tangible, measureable skills are attained, the conning officer must learn and master skills that are more difficult to explain and are more difficult to measure.

a. Determining What is Happening

In order to make relevant and timely commands to the helm, the conning officer must be able to see what is happening. This can be difficult to do while handling a ship at slow speeds, or alongside an oiler during an UNREP, or out to sea in the middle of the night. There are certain skills that must be developed in order for the conning officer to become a capable shiphandler.

(1) Seaman's eye

Seaman's eye is a critical skill that is hard to train directly, yet it is a critical aspect of any shiphandling evolution: "Seaman's eye consists of the learned skills of timing and execution of planned maneuvers based on observation of all of the forces working on the ship" (Barber, 2005). A conning officer can only hone it by practice and experience. It does not consist of any one skill or observation, but the sum of all the conning officer's observation. For example, if the conn is taking the ship pier side, it is critical for them to know exactly what both the bow and stern are doing in relation to each other, in addition to the overall speed and direction of the ship. Determining this is not easy, and requires the conn to take many factors into account. First, they make look at the jackstaff on the bow and watch the movement of it against a stationary object beyond to get an idea of what the bow is doing. They then may do the same aft, making sure the stern is not moving towards the pier faster than the bow. After that they might look at a flag on the pier to see what the wind is down, and then look straight down to the water from the bridge to determine when the ship stops moving or makes sternway. All of these factors must be looked at by the conning officer, and they must be able to determine what is happening immediately.

(2) Relative motion

Honing the seaman's eye requires that the conning officer have a healthy understanding of relative motion. This is an absolutely critical skill and is another one that takes practice to truly understand and apply it. It applies to every aspect of handling a ship, not just taking a ship pierside. It is a major part of moboards, which is a direct application of relative motion. One can learn the steps and complete the vector mathematics involved in computing a moboard solution without truly understanding what the answer means, but once the officer understands it, they will be a much more capable mariner.

b. Deciding Correct Action (i.e., What You Want the Ship To Do)

Once the conning officer understands the situation, whether it is a contact in open water or the final approach to the pier, they must decide on the correct action. Most of the time, this is where the CO or OOD will be working with the conn, but it is important that the conn not merely parrot the CO's or OOD's orders. They must understand what needs to be done and know what to do about it in order to progress to higher responsibilities.

(1) Rules to follow

The first step in determining correct action in a situation is applying the written rules. These will give the conning officer guidelines on what to do in most situations, and can at least give the conn a good first step. There written rules include the international COLREGS or "Rules of the Road" (United States Coast Guard, 2015), the CO's standing orders, and any local rules or regulations.

(2) Get in "front of the problem"

Another major part of deciding on correct action is deciding on that action as early as possible. When the conning officer first notices indications that a situation is developing, such as the ship not moving as desired in close quarters, it is critical that the conning officer use their skills to see this and "get in front of the problem." This means that as soon as they see something, they make a small order to correct early. Correcting a situation early with a small, simple order is much more desirable than a massive correction at the last minute to avoid collision. In order to do this, the conning officer must have an absolute understanding of what tools are at their disposal.

c. Making it Happen

The conning officer needs to understand all of the forces acting on the ship in order to maneuver the ship smartly. These forces can be broken down broadly into controllable and uncontrollable forces. Controllable forces are those that the bridge personnel can control, such as the ship's engines, rudder, tugs, and lines. CAPT Barber breaks controllable forces down further into directly controllable forces and indirectly controlled forces, with indirectly controlled forces being those that can be controlled by remote communication, those being tugs, lines, and the anchors (Barber, 2005). Uncontrollable forces are those which bridge personnel cannot control, such as wind and current. The ship will move "in response to the vector sum of all of the forces exerted upon it. Some of these forces are under our control, some are not. A prerequisite to becoming a competent shiphandler is to understand all of those forces, how they affect the ship, and how they interact" (Barber, 2005). Once the conning officer understands all of these forces, how they interact, and how to use them, they must be able to quickly and succinctly issue the standard commands required to move the ship as desired using all of the forces interacting with the ship.

d. Verifying That Results Are as Desired

Shiphandling requires constant attention and constant correction. There are so many variables at play that once an order is given, the conning officer must continue to watch and feel what is happening, both to verify that the previous action is having the desired effect as well as determining what is required next. Even a perfect order will likely need a correction or update shortly. The conning officer must continue to use their knowledge of the ship's characteristics, their seaman's eye, knowledge of relative motion, and the controllable and uncontrollable forces to continually adjust and make corrections and give orders to safely navigate the ship.

3. How Conning is Trained Now

The first step for a new SWO following commissioning is directly to the Basic Division Officer Course (BDOC) in either San Diego, CA or Norfolk, VA. Most attend prior to reporting to their first ship, and the few who do not will begin BDOC within three months of reporting aboard. This is where SWOs first start to learn the art and science of shiphandling. They receive lectures, showing them the basics and discussing standard commands. After that, they start working in the Conning Officer Virtual Environment (COVE) simulator. The students will wear a head mounted display (HMD) and speak standard commands into a microphone to control a ship in this high fidelity simulation. They will have multiple COVE sessions throughout their two months at BDOC, and this is the time where they get the most "sets and reps" handling a ship.

After BDOC, the junior SWOs report to their ships and take on the full duties of a division officer. Shiphandling training will continue, but not nearly with the frequency as it was at BDOC, especially if the ship is not often underway, such as when it is in a maintenance availability. All the junior SWOs on the ship are competing for conning time during special evolutions, and often there simply is not enough to go around. SWOs do not have access to COVE simulators once they get to a ship. There is allotted time in the Navigation, Seamanship, and Shiphandling Trainers(NSST), but those are designed for full bridge teams instead of individual officers working on basic concepts. This leads to some junior SWOs being left behind in terms of shiphandling capability.

4. Current Difficulties

There have been multiple high profile collisions and groundings in recent years for the U.S. Navy. All of these have been due to different circumstances and situations, but the shiphandling expertise of the COs and/or the officers they qualified and their bridge teams is of upmost importance. These mishaps highlight this and remind mariners that "the business of going to sea is, and always has been, subject to hazard" (Barber, 2005).

a. List of Incidents

In 2017, there were two high profile collisions with commercial vessels, the USS Fitzgerald (DDG-62) and USS McCain (DDG-56), within two months of each other, result in the deaths of 17 sailors (Navy Office of Information, 2017). Both of these collisions happened during routine operations with qualified officers on the bridge. Additionally, in 2017, the USS Antietam (CG-54) ran aground in Tokyo Bay (Hlavac, 2017) and the USS Lake Champlain (CG-57) collided with a Japanese fishing vessel (Navy Office of Information, 2017). In 2013 the USS Guardian (MCM-5) ran aground (US Pacific Fleet Public Affairs, 2013), leading to the loss of the vessel. In 2012 the USS Porter collided with a merchant vessel in the Straits of Hormuz (LaGrone, 2012) and in 2009, there was the grounding of the USS Port Royal (CG-73) (Konrad, 2009).

b. Potential Causes

The COs and officers on the bridge are not completely to blame in all of these incidents, but it is a disturbing trend. Even if there was a malfunction in equipment or the chart was wrong or it was the commercial vessels fault, our job as SWOs is the safe navigation of the ship, and there can be no excuses. Most of these collisions seemed to be partially due to a lacking bridge team that either did not know what to do in extremis or was not confident enough to speak up. Either way, this shows a lack of knowledge and ability amongst junior SWOs, and this was shown in a separate 2018 study.

c. JO Shiphandling Study

In 2018 the Navy conducted a three-month review of junior SWOs shiphandling abilities across seven different fleet concentration areas (FCAs) and found concerns with 85% of the officers tested (Larter, 2018). The primary concerns found in this study, such as a lack of understanding of radar, applying rules of the road, and taking the correct action in extremis, were found to be major causes of the Fitzgerald and McCain collisions (Larter, 2018). Although the Navy is taking action to address these issues, such as increasing radar time in COVE from 2 to 11 hours at BDOC, these results show a general lack of shiphandling ability across the fleet that will require additional efforts to correct.

5. Importance for JOs

Shiphandling has long been at the core of what surface warfare officers do and will remain so for the foreseeable future. A CO cannot always rely on the harbor pilot's judgement, especially overseas, and never knows when they will have to conduct a complicated shiphandling evolution with limited assistance. Despite this, it is expected that COs will be able to safely handle their ships in almost all conditions. This level of expertise is not acquired overnight or through one good training program; instead, it is acquired throughout a career of practicing and refining the skills required to become an expert shiphandler. This starts on day one for a SWO, as the first two tours are when the officer will get the vast majority of their time as the conning officer.

B. MOTIVATION

The importance of shiphandling and the current poor state of shiphandling in the fleet motivated us to pursue this topic. According to Dreyfus and Dreyfus' five stage model of expertise, experience under a wide range of scenarios and conditions is required to improve between the stages to eventually reach expertise (Dreyfus & Dreyfus, 1980). The fact that many evolutions are so rare and the large number of junior officers aboard most ships means that most officers cannot perform many evolutions enough times to gain the experience required to move to expertise. The Navy attempts to address this by the use of simulators to allow officers to get more experience at these evolutions, but current simulators are large, costly, and require the use of an instructor or contractor to operate.

Computing power has reached the point where useful shiphandling simulators can run on systems that every officer has routine access to, such as desktop or even mobile devices. Such systems would allow officers to practice a wide range of shiphandling evolutions multiple times. In this thesis, we built and evaluated the effectiveness of a mobile shiphandling trainer designed to teach low-speed maneuvering and the forces that act on a ship.

C. RESEARCH QUESTIONS

Shiphandling is a very complex task that has many variables that the conning officer needs to understand and keep track of. In order to organize our approach to this problem, I focused on the following seven questions. There are two main themes to these questions, these being the aspects of shiphandling that can be adapted to a mobile device and could access to training to these tasks on a mobile device increase shiphandling capability in the user.

1. What aspects of shiphandling can be adequately implemented on a mobile device?

2. What training scenarios in addition to general shiphandling could be implemented on a mobile device?

3. What visual aids would add value to the application?

4. Can ready access to a shiphandling trainer improve junior SWO shiphandling knowledge and skills?

5. Given the technical limitations of current mobile devices, what shiphandling tasks can be simulated to support shiphandling training?

6. What is the training effectiveness of using a mobile device for shiphandling?

7. What design features will enhance effectiveness on a mobile device?

D. SCOPE

This thesis developed an application that can be used on a desktop computer, laptop, tablet, or even phone that enables officers to practice shiphandling in a low-stress, low-cost way. At the most basic level, we assumed that everyone has either access to a modern mobile device, whether it was a tablet or smartphone. Given that the computational power and screen space are the limiting factors of a smartphone, we kept this in mind while developing this application, and limited the scope of the trainer accordingly. This trainer will enable officers to experiment with different orders to engines and rudders, in addition to the effects external forces such as wind and current have on the ship. By allowing officers to practice with orders and visualize the effects of these orders, we can enhance the value of more the expensive training time such as NSS training or underway.

E. APPROACH

1. Training Application

We envisioned this application to be optimized for use on personal devices, in this case an 8-inch tablet. The user would be able to control the port and starboard engines, the rudder, and a single tug boat attached to the bow of the user's ship. A key aspect would be that the forces each of these exerted on the ship would be shown as vectors in real time. The resultant movement vectors of the bow, stern, and overall ship would also be shown, as these are a sum of all the forces acting on the ship. The pivot point would also be depicted so that users could see how it shifts in different conditions. Additionally, the user would be able set wind and current and would be able to conduct different, built in scenarios.

2. Training Effectiveness Study

For the training effectiveness study, it was decided to focus on junior SWO's attending BDOC. These officers are the ones that are learning basic shiphandling and will have little to no experience, so they are starting from scratch. A lot of time already devoted to training shiphandling at BDOC, and these officers have no other collateral duties. Another added advantage to focusing on this group is that they are all starting at the same level of experience for the most part. Some of them might have spent a little time on their ship before reporting to BDOC, but for the most part shiphandling at BDOC is their first exposure to it.

Shiphandling training at BDOC starts during the first few weeks with a lecture. From there they have COVE sessions for the remainder of BDOC. These sessions start with open ocean transits and man overboard drills to get the concepts down, and then shift to pier work, with students practicing getting the ship underway and bringing the ship pierside. They then work on contact management in congested areas, including pier work at the end.

After each run, the instructor fills out a grade sheet on how that student did. It was decided to use these for the study as they are the only evaluation of the student's performance. In our experiment, half the students to use the application before performing a simple COVE scenario, and half did not. Their scores were analyzed looking for a difference in performance between the experimental group (students who used the application) and the control group (those who did not). Every student in the experiment, as well as several who used the application, were given a questionnaire which asked them to share their impressions of the system.

F. THESIS STRUCTURE

The remaining chapters of this thesis are laid out as follows:

1. Introduction – This chapter provides an introduction to the problem and research question that were looked at.

2. Background – This chapter gives an overview of current training approaches in shiphandling, a summary of mobile devices and their uses as a partial task trainer, and an overview of the Unity game engine.

3. Shiphandling Trainer – This chapter describes the application developed in detail.

4. Training Effectiveness Study – This chapter discusses the approach of the training effectiveness study and provides an analysis of the results.

5. Conclusions and Recommendations – This chapter offers conclusions based on the results of the study, and provides recommendations for future work.

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II. BACKGROUND

A. PROBLEM SPACE

1. Learning Shiphandling as a Junior SWO

For some officers, effectively conning the ship comes naturally. But for most, it feels unnatural and difficult, even if they are comfortable with standard commands. They have trouble visualizing the effects of all the forces acting on the ship, especially in low speed situations that require a high degree of precision. There are many tools the Navy uses to train officers in shiphandling, and has spent a lot of money on high fidelity simulators. This thesis looked at the development and potential benefit of a low fidelity partial task trainer built for personal devices.

2. Existing Training Summary

The obvious answer to this is for these officers to practice more and the Navy provides excellent systems to assist with this. The COVE system is a beneficial tool used at BDOC and Surface Warfare Officers School (SWOS), but those are the only times officers will use this system. After they leave training they will not use the system again until they are back for Advanced Division Officer Course (ADOC) or Department Head School. This is not adequate for junior officers who are expected to conn the ship. The follow-up training to this is conducted at the NSS trainers located in all of the FCAs. These are useful, but in today's environment they are not efficient. Ships are only required to complete 60 hours of special evolutions training per year, and have the option of using up to 20 additional hours (COMNAVSURFPAC and COMNAVSURFLANT, 2018). In my experience, ships will only be concerned with meeting the minimum time requirement, as there seems to always be something more important, whether that be the next inspection or more administrative work for the junior officers. In addition to this, those NSST hours are for the entire ship, and ships have more ensigns than the NSSTs can provide simulated conning time for. This means even less training time for these officers. The same issues exist for practicing conning the ship at sea. Operational requirements always come first and keeping a ship at sea is expensive, this means the amount of time that most ensigns will have actually learning how to drive the ship is extremely limited.

3. Allow Experiment and Fail

Additionally, one of the key parts of effective learning is the ability to experiment and fail. However, failure at sea would likely result in the relief of the commanding officer, so CO's are extremely hesitant to actually let junior officers conn in restricted waters. Instead, the conning officers are really just standing near their CO's and repeating their orders. The junior officers have little time to try to think how they would solve the current situation before the CO has given an order, one oftentimes the conning officer does not understand the rationale for. During these evolutions, there is no time for the CO to give a rationale for their order, and specific orders are rarely debriefed and explained afterwards.

B. CURRENT SURFACE FORCE SHIPHANDLING TRAINING TECHNOLOGIES AND METHODS

1. Navigation, Seamanship, and Shiphandling Trainers (NSST)

The NSS trainer is a high fidelity, full mission bridge simulator located in fleet concentration a (FCAs). The NSST's use the Polaris V2 by Kongsberg. The high fidelity models "provide maneuvering characteristics virtually identical to real world operations, augmented by high fidelity radar and navigation instruments" (COMNAVSURFPAC and COMNAVSURFLANT, 2018). Environmental conditions are also completely customizable, allowing any desired scenario to be trained to.

The NSS trainer is utilized by ships as a whole, not individual officers. COMNAVSURFPAC/COMNAVSURFLANT instruction 3505.1B establishes the requirements for NSST for the entire fleet. There are two primary, required NSST courses. The first is the Bridge Resource Management (BRM) course. This is a 40-hour course that is required once per the CO's tour. Three bridge watch teams consisting of at least the officer of the deck (OOD), junior officer of the deck (JOOD), conning officer(CONN), and combat information center watch officer (CICWO) are sent to NSST for a week with the CO required to be there for the entirety of the course.

The BRM course does not focus on shiphandling, but instead the overall management of the watch team while conducting a shiphandling scenario. Multiple briefs are conducted throughout the week, looking at topics such as situational awareness, error chains, decision making, leadership, and rules of the road. (Bridge resource management course, n.d.) The watchteam will also look at multiple case studies, as well as plan and execute a scenario in the simulator later in the week.

Special evolutions training (SET) is the other NSST course, and 60 hours of SET is required for each ship annually, with an optional additional 20 hours (COMNAVSURFPAC and COMNAVSURFLANT, 2018). SET lets the CO decide which scenarios they would like their watch teams to work on, this can range from home port transits to specific scenarios like towing or conducting an underway replenishment (UNREP). The Basic Shiphandling Course (BSH) is contained within allocated SET time. It is tailored for novices and works through the basics of shiphandling throughout the course of the week. There are 10 hours of instruction and 30 hours of shiphandling in the simulator, and the class size is capped at six students to ensure sufficient time in the simulator (Basic ship-handling course, n.d.). The 10 shiphandling lessons are an Introduction, Forces on the Ship, Standard Commands, Getting Underway, Making a landing, Rules of the Road, Underway Replenishment, Man Overboard, Tactical Maneuvering, and Anchoring. BSH concludes with a test of four scenarios assessed by an instructor (Basic ship-handling course, n.d.).

The NSS trainer is an excellent tool for COs to get their watch teams experience and time practicing in high fidelity simulations. The BSH course in particular is an excellent tool, providing expert instruction on shiphandling and letting the students practice immediately afterwards.

The NSS trainer is not without its shortfalls though. This is due to the nature the timing in which junior officers report to their ships, and the allocation of annual training hours to each ship. Because the BSH course is a part of SET hours, it limits how much time a CO can use these SET hours for more complicated scenarios. Realistically a ship will conduct one BSH course a year, as it uses 40 of the 60 SET hours. Since BSH can only support 6 officers at a time, it can be easy for junior SWOS to never have the opportunity to attend the course.

Another disadvantage of NSST is that officers cannot return at will to practice. Some may need more time to practice simple concepts, and may be left behind because they do not have the chance to use the skills learned more. An individual SWO, even if they attend every session a ship is allocated, does not get enough conning time in the simulator.

2. Conning Officer Virtual Environment (COVE)

COVE is the second of the TYCOM approved shiphandling simulators. It is also high fidelity, with characteristics that are "virtually identical" to real world scenarios. It also has highly controllable environmental, allowing for any conceivable scenario to be practiced. COVE can support both individual and group training, either with a headset or in a full mission bridge. Another significant feature is that it is voice activated, allowing for officers to practice standard commands in a realistic manner.

COVE is the primary simulator used by SWOS in Newport, RI as well as at BDOC in San Diego, CA, and Norfolk, VA, with a full mission bridge simulator located at SWOS in Newport, RI. Most SWOs now are first introduced to handling a ship at BDOC, where instructors start from ground zero to build a foundation for these junior SWOs. This starts with a brief, where the basic ideas are explained and drawn on the white board. They explain the differences in controllable and uncontrollable forces, and show how these forces affect the ship. After this, students are put into COVE for the first time, where they are put in basic scenarios to practice standard commands and get a feel for the ship and how everything works in COVE. From there they work through increasingly difficult scenarios throughout the two months at BDOC.

COVE is also used for all of the advanced courses at SWOS in Newport, RI, from ADOC and DH school to the prospective CO/XO course. At SWOS, in addition to the voice controlled headsets, they also use the full mission bridge for more advanced, team-based scenarios. COVE is an excellent training tool, and at BDOC is invaluable in initial training for junior SWOs. While once they get to the fleet shiphandling is a team effort, at

BDOC it is the focal point and the student is the only one in control during a COVE session forces them to learn, and makes it more apparent if someone is not where they need to be. Being voice controlled, it allows these junior SWOs to practice and become competent in standard commands before they ever set foot on a ship.

It does have some disadvantages though. First, a SWO's exposure to COVE is limited to specific training courses. These courses are spread throughout their careers, and almost always serve as either an initial introduction to shiphandling or as a refresher. Being high fidelity, COVE is a very complicated system and requires one instructor per station to run it. At BDOC, there are three students assigned to each COVE station with one instructor. While one student is in the simulator conducting the scenario, the other two students are watching the first conn the ship. This is "dead" time where the students are not necessarily engaged, even though it counts as time in COVE. Students only get out what they put in at those times. This is just the nature of a complicated, high fidelity simulator and that there will never be a 1–1 student instructor ratio.

3. Underway

The traditional method of training junior SWOs shiphandling is train them while underway. Before the advent of BDOC, newly commissioned SWOs would report straight to their ships, without any sort of training pipeline. This puts officers commissioned through reserve officer training corps (ROTC), Seaman to Admiral-21 program (STA-21), and officer candidate school (OCS) at a significant disadvantage compared to officers commissioned through USNA, who tend to have more exposure to the basics of shiphandling, standard commands, and standing watch on the bridge. All Naval Academy graduates will have had some exposure to yard patrol craft (YPs), training vessels used to teach midshipman the basics of shiphandling. Time on the YPs are a good introduction to shiphandling and an excellent introduction to using standard commands, which tend to have a steep learning curve. SWOs from USNA and ROTC will also have completed at least one summer cruise aboard a naval vessel, where they will have had a fair amount of exposure to shiphandling and bridge watch. ROTC and OCS graduates do not have the same opportunities as their USNA brethren, and were at a disadvantage before BDOC.

Shiphandling training underway with the CO or a DH usually consists of the CO taking out his/her pen or pencil and explaining all of the controllable and uncontrollable forces and moving the pen around to try and show how you would maneuver the ship in different ways, such as a port or starboard twist. The first time the SWO takes the conn will almost always be in open ocean when the CO has time and space to allow the junior SWOs to practice. One way they do this by conducting man overboard skills, a critical ability for any SWO and an excellent introduction to the finer points of handling a ship at low speeds. This is an easy, safe way for CO's to introduce and junior SWOs to practice low speed shiphandling, the same skills required for going pier side and getting underway.

The advantage of this method is that while it is a steep learning curve, if there is time in the ship's schedule it is an excellent way to train a SWO, and it will never go away or lose viability. Actually driving the ship out at sea and seeing how everything fits together is invaluable. The biggest issue is time and money, keeping a ship at sea is expensive. There are also a lot of officers that need time to practice shiphandling, and only so much time can be devoted to this while at sea. Sadly, there are usually greater priorities, whether it be the next big inspection or the daily, 24/7 duties of a division officer. Realistically any given officer cannot be given the amount of time required to really practice and hone their craft.

C. MOBILE GAMES

1. Definition

Defining a mobile game comes down to defining what kind of device that particular game was developed for. Mayra (2015) noted that one could consider games developed for handheld devices and laptops to be mobile games. He also pointed out that games developed for handheld devices tend to be more closely related to the video game console market. Games developed for personal computers could be categorized similarly, as lot of those games are developed for both consoles and personal computers simultaneously. In this thesis, we expand Mayra's definition to include tablets as mobile games.

a. What Makes a Game Mobile?

A mobile game is a game developed specifically for a mobile phone or tablet. These games are designed to be casual, meaning they are usually either free or very cheap, and very simple. This is a function of both the capabilities of these mobile devices and the people using these devices. Screen space and memory are at a premium, and they do not allow for high end graphics or complicated UIs: "Based on earlier, trusted gameplay formulas, such casual games make efficient use of both touch screen interface and the audiovisual strengths of smartphones' processor and memory capabilities" (Mayra, 2015).

In mobile games, the user input is almost exclusively done using the touch screen. This is very different from the other gaming markets, where the user interacts with the game using some type of controller or a mouse and keyboard. This restricted environment keeps mobile games casual because small screen size and limited controls severely restricts how complicated developers can make a game. Figure 1 shows a shipment forecast by screen size out to the year 2021, and it is apparent that phones will most likely not be getting much bigger.

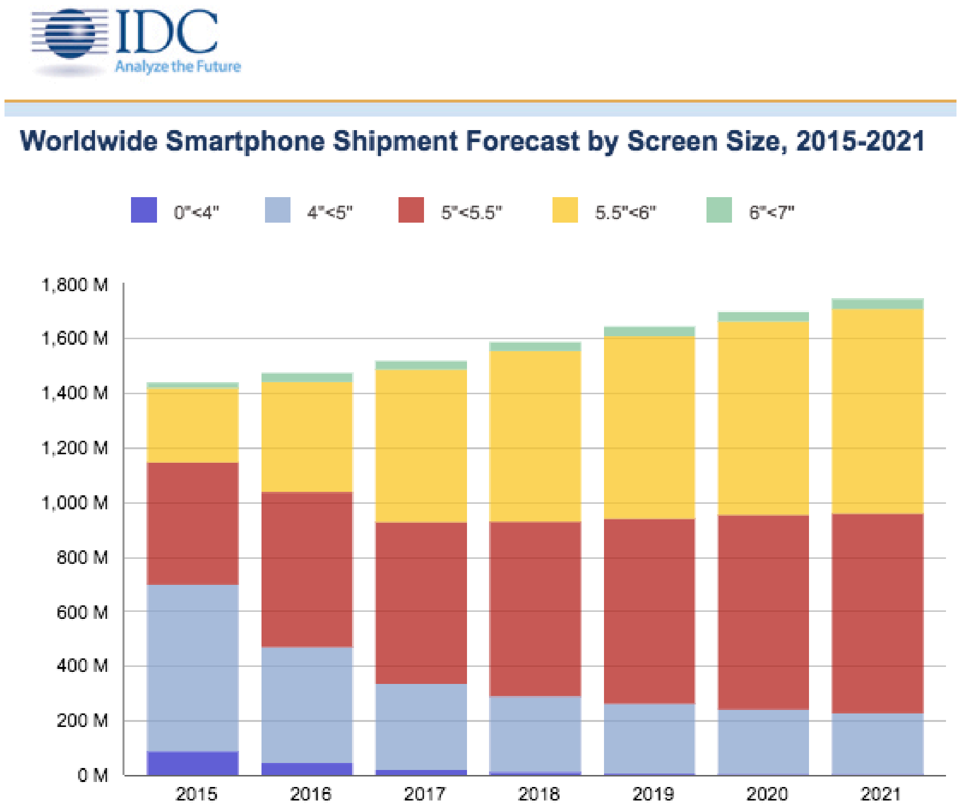

Figure 1. Worldwide Smartphone Shipment Forecast by Screen Size. Source: Shirer, Reith, Scarsella, and Chau (2017).

b. Audience and Popularity

(1) Number of Users

Mobile devices are becoming an increasingly important part of American society. Smartphone and tablets ownership have both been increasing steadily. A Pew Research center survey has found that smartphone ownership in America has increased from 35% in May of 2011 to 77% in January of 2018 as shown in Figure 2. Tablets have also enjoyed a massive gain in ownership, increasing from just 3% of Americans owning one in May of 2010 to 53% in January of 2018, also shown in Figure 3. These ownership numbers also vary by age, with 94% of people from ages 18–29 owning a smartphone, to just 46% of people aged 65+ owning one (Pew Research Center, 2018).

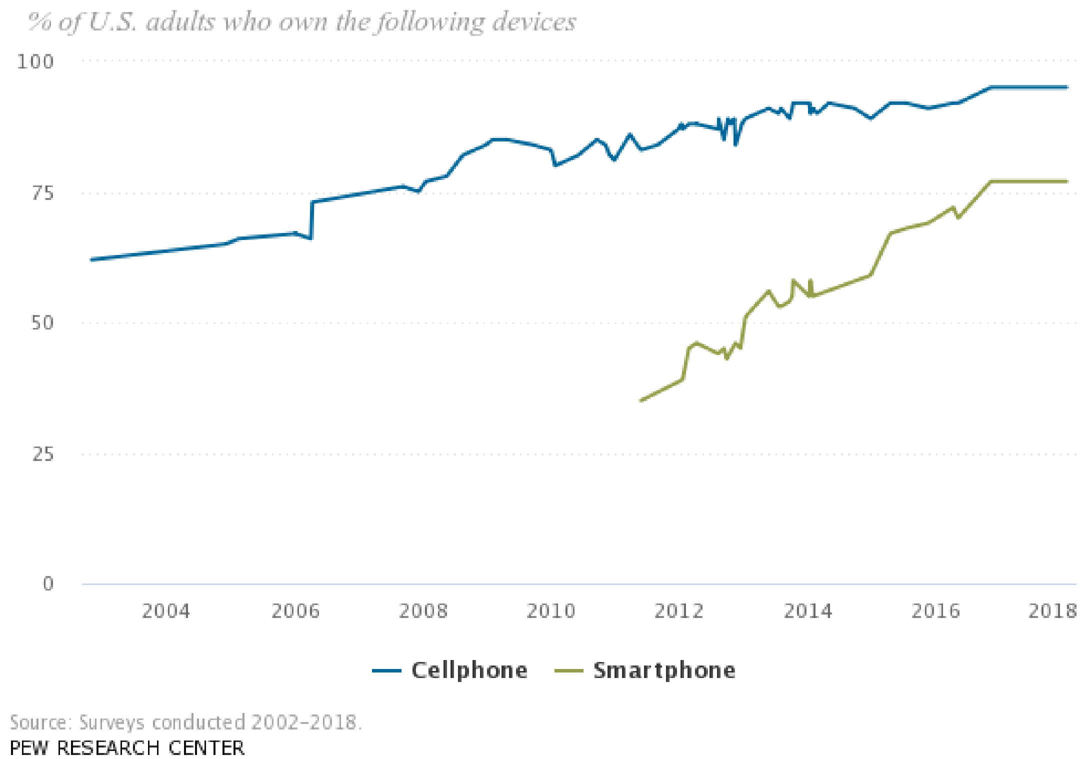

Figure 2. Percentage of U.S. Adults Who Own Cellphone and Smartphone. Source: Pew Research Center (2018).

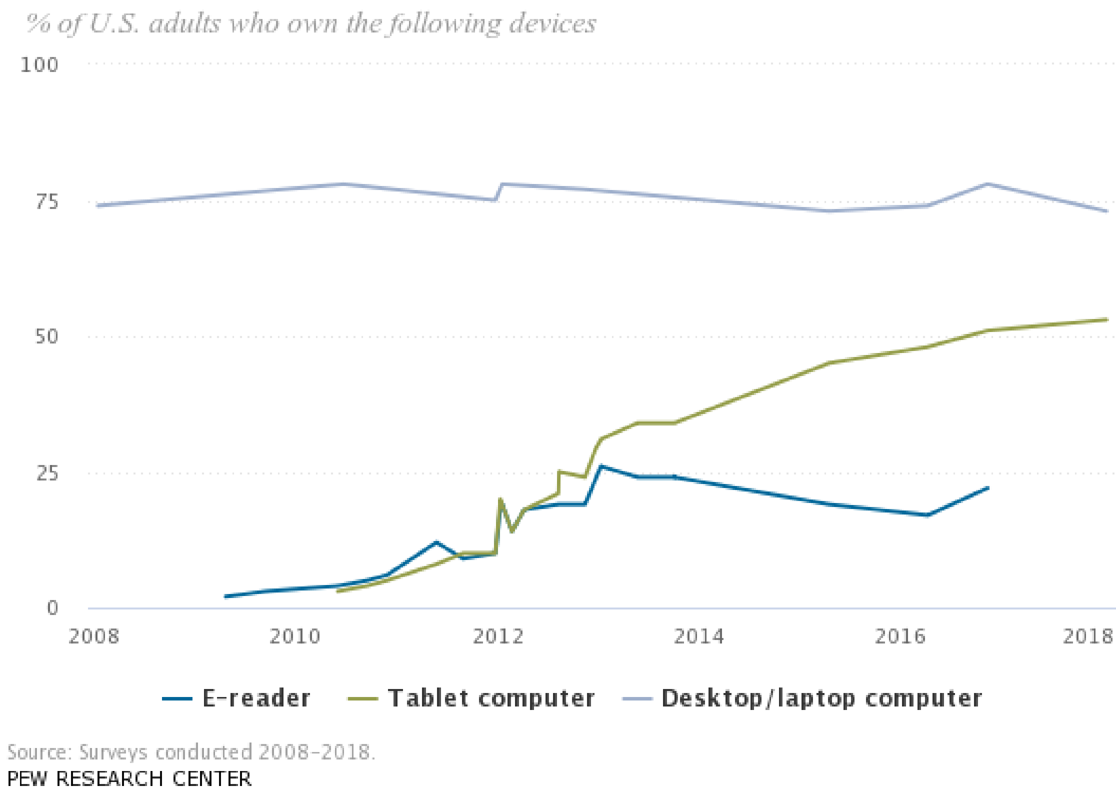

Figure 3. Percentage of U.S. Adults Who Own E-reader, Tablet, and/or Computer. Source: Pew Research Center (2018).

(2) Popularity of Mobile Games

With the rising ownership and popularity of both mobile phones and mobile devices, mobile games have become incredibly popular and lucrative for game developers. According to statista.com, as of 2017 there are over 100 million people that play mobile games on either their smartphone or tablet (Statista, n.d.). This explosion of mobile game popularity is due to a number of factors, with the different app stores, better quality games, faster cellular networks, and more powerful mobile devices all contributing (Mayra, 2015).

(3) Mobile Game Market

The market for mobile games, which includes both smartphones and tablets, is now 51% of the $137.9 billion global gaming market according to the video game analytics company Newzoo (Wijman, 2018). Every smartphone can act as a gaming platform, and this in combination with the proliferation of smartphones worldwide has led to the boom of the mobile game market. As smartphones continue to increase in quality and number, the mobile game market will continue to grow as well.

What all of this illustrates is that mobile devices and mobile games are mainstream, and are no longer just used by early adapters. The vast majority of American own smartphones now, especially younger Americans, and a great deal of these users play and spend money on mobile games.

D. MOBILE DEVICES FOR TRAINING

1. Partial Task Trainer

There are many components to shiphandling, making it an extremely complex endeavor which takes a significant amount of time to master. There are, however, a few key concepts that are critical for junior officers to understand in order for them to become capable mariners. Understanding how controllable and uncontrollable forces affect the bow, stern, and overall motion of the ship is critical. The directly controllable forces being the engines and rudder, indirectly controllable forces being mooring lines, anchors, and tugs (Barber, 2005). Finally, the uncontrollable forces that ship drivers must take into account are wind and current. All of these different forces interact with the ship, and the junior officer must take all into account when they have the conn.

A partial task trainer focus on a very specific part of a task and trains that in a vacuum. It allows a complex task to be broken down into discrete parts so that the trainee can focus on one aspect of an overall task. Mobile devices are perfect for this, since a partial task trainer is by nature less complicated than the actual task. This means that a partial task trainer can be and should be lower fidelity than a full simulation, allowing us to take advantage of the prevalence of mobile devices

2. Limitations

There are a few limitations to using mobile devices as partial task trainers that need to be mentioned. Screen size, computing power, and how these two impact the fidelity of the trainer are major limitations. The average screen size for a smart phone is between 5 and 5.6 inches and tablets range from 5 inches to over 10 inches (Best, 2015). This is not a lot of space for both the visual part of the trainer as well as the input controls, as most phones and tablets do not use external input devices.

Another limiting factor is computing power, though this is less impactful than screen space. This also becomes less of a concern each passing year, as computing power gets cheaper and smaller, allowing mobile devices to be able to handle more graphics intensive software. An article published by WIRED in 2015 talked about how in less than two years, some people will only use smartphones for their computing "thanks to increased processing power, better battery life, vastly improved networking speeds, and larger screen sizes on mobile devices, the shift away from the desktop is accelerating" (Bonnington, 2015).

The biggest limiting factor ends up being screen space. A mouse and a keyboard or a full size simulator allows limitless user inputs, but when limited to a small mobile screen, user inputs become limited to only a few. This is critical when looking at mobile devices for partial task trainers, because it forces you to scale down the fidelity of the simulation.

E. PAST WORK

1. Mobile Interactive Training: Tablets, Readers, and Phones

A paper written for the Interservice/Industry Training, Simulation, and Education Conference (I/ITSEC) in 2011 by Jo McDonald, Eric Foster, Joyce Divina, and David Donelly looked at using mobile devices to field interactive Navy Non-Resident Training Courses (NRTCs) (MacDonald, Foster, Divina, & Donnely, 2011). NTRCS are self-taught navy courses for enlisted personnel, and began utilizing "level III-interactive PDFs with user-controlled animations, audio, videos, 3D images, and graded assessments with bi-directional remediation" (MacDonald, Foster, Divina, & Donnely, 2011). The paper looked to utilize mobile devices for these level III-interactive PDFs for young enlisted personal to conduct these courses on their mobile devices.

There were two primary motivations for the authors, first the fact that "learning is significantly increased when training is presented via well-designed multimedia" (MacDonald, Foster, Divina, & Donnely, 2011). Secondly, "most young people, including the Soldiers, Sailors, Airmen, and Marines of today's military, use hand-held devices such as smartphones and tablets on a daily basis" (MacDonald, Foster, Divina, & Donnely, 2011). The authors wanted to take advantage of the fact that today's young people use their mobile devices for nearly everything, "the applications resident on them and available from them via the Internet—are always present, always accessible" (MacDonald, Foster, Divina, & Donnely, 2011).

The authors found many benefits to using mobile devices for this training. First, it benefits the user, because they are able to do the training when and where they would like, and "they will have ready access to just-in-time training to refresh their skills on the job" (MacDonald, Foster, Divina, & Donnely, 2011). There is also cost benefit, after the initial development the cost goes to zero, which of course benefits the training organization (MacDonald, Foster, Divina, & Donnely, 2011). They also discussed the actual training benefits, namely "It brings the training source to trainees for use when they want it and when they need it, leveraging the capabilities and ubiquity of mobile technology to provide totally self-directed learning" (MacDonald, Foster, Divina, & Donnely, 2011).

This paper applies directly to this thesis, as we are looking to leverage the same advantages of mobile devices as the authors. While the authors looked at using mobile devices for learning material, we are looking at them for learning concepts and specific real world tasks. The advantages remain the same in both situations however, as allowing junior officers to practice shiphandling on their own time with their own device as much as they want would augment current training practices.

2. A Tablet Based Virtual Environment for Neurosurgery Training

A Tablet-Based Virtual Environment for Neurosurgery Training looked at using a tablet-based application to supplement training for a ventriculostomy procedure. The researchers in this case developed an application called VCath for use on a 3rd generation iPad to be used before conducting the procedure on a Rowena head model (John et al., 2015). VCath is a low fidelity simulation that the researchers tested as a training tool (John et al., 2015).

The researchers found that the VCath app had a positive effect on performance (John et al., 2015). "The VCath app is successful as it is focused on the cognitive task of ventriculostomy, encouraging the trainee to rehearse the entry point and use anatomical landmarks to create a trajectory to the target" (John et al., 2015). This directly relates to this thesis, and shows that low fidelity trainer can improve performance of a task.

F. UNITY

1. Overview

Unity is a game engine and editor that is used to by both industry and individual developers to create video games. It includes a very capable editor that includes a multitude of tools that "enable rapid editing and iteration in your development cycles" (Unity 2018, 2018). Unity includes a physics engine, a user interface system, 2D and 3D, and a "strong suite of developer tools for implementing game logic and high performance gameplay" (Unity 2018, 2018).

2. Capabilities

Unity has a vast array of capabilities that makes it appealing for a project like this, especially for a single student working to bring a training application to a training audience. Between the editor, 2D/3D functionality, User interfaces, play mode, and more, Unity's capabilities make it ideal for rapidly developing a prototype.

First, the built-in physics engine is a critical capability. This physics engine provides the different functions and abilities to make an object behave realistically according to physics, letting the user worry about how to apply these forces and physics to make the objects behave the way they want them to. Unity has two separate physics engines, one for 3D environments and one for 2D environments. They are separate but have similar components, making it easy to for the user work in the other mode if they are comfortable in one (Unity 2018, 2018).

Unity also includes an intuitive user interface system for building a functional UI for a game. The UI system has many features that allow rapid prototyping, making is easy to add menus to an existing game, and building a control interface on top of the game itself for the user to interact with the game. The Unity editor's playmode is another capability that allows rapid testing. The play mode lets the developer "play" the game whenever they want while developing, without having to compile or build anything. All of the editor's windows will remain open as well, letting the developer see values and attributes that would normally be hidden, allowing for rapid troubleshooting in real time.

3. Why We Used Unity

We decided to use Unity for this application for all of the reasons listed above. First, Unity is very user friendly, and there is a plethora of tutorials on the website. There are 23 different topics with 722 different tutorials amongst these topics. Unity also provides 14 free, full projects. Each of these projects includes the final product, as well as all required assets to follow along with the tutorial videos. These tutorial projects are a great way to get started with Unity, and will also show more advanced topics in a guided, controlled manner. The Unity tutorials won the "2018 Developer Choice awards for Tutorials and How-To Videos" (Unity 2018, 2018).

Another factor was how user friendly Unity is, and the array of supporting resources with the ability to rapidly test an application with play mode. This allowed me to take a prototype, and with minimum experience in Unity build on the prototype to add features and refine the application. A full build or compile is not required to use the software while developing, so it allows rapid testing and troubleshooting. This allowed us to quickly develop a prototype, refine it, and test it on the target platform with the target audience.

Unity supports 27 different platforms, the most of any game development software. It is very simple to use, and with one click you can build the application for any of these platforms. When building a game for a mobile device, Unity is optimized to utilize a mobile device's touch screen with no extra work. Once ready for testing on a mobile device, all that is required is to build the application for the device's operating system and press play.

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III. SHIP HANDLING TRAINER

A. INTRODUCTION

The Shiphandling Trainer was built as an application (app) for use on a mobile, touchscreen device. The focus of the app is on the ship which is always in the middle of the screen, and the primary view is looking at the top of the ship. The ship's screws are visible and spin at different speeds based upon the ordered bell, and the rudders are also visible and reflect their ordered position. The UI allows the user to fully control engine and rudders and the ship will react to these controls. There are other items which impart information not normally and will show the resultant pivot point and vectors on the bow, stern, and the ship overall.

1. General Approach

As discussed earlier, there are multiple forces acting on a ship at any time. The forces the ship's crew can control are consist of the effects of engines, rudders, tugs, anchors, lines, thrusters, replenishment rigs. The uncontrollable forces are wind, current, and the Bernoulli effect when operating alongside another vessel. Figure 4 shows all these forces acting on a ship.

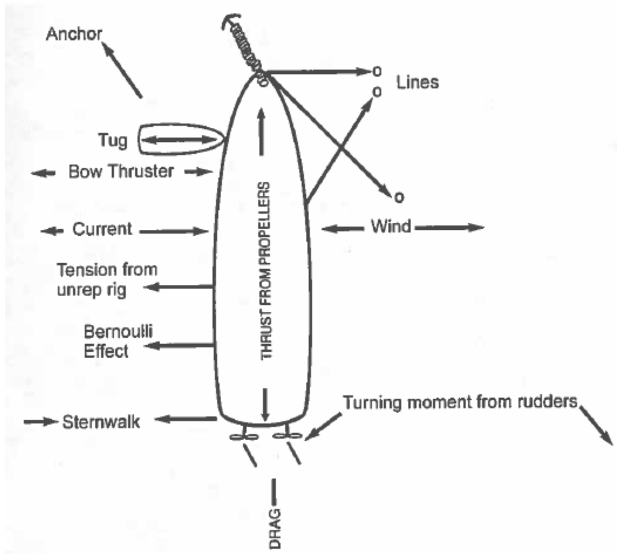


Figure 4. Forces Enacted on the Ship. Source: Barber (2005).

For this app, we wanted to provide a trainer that allowed real time manipulation and visualization of most of these forces. We ignored the Bernoulli effect and tension from a replenishment rig because conducting replenishment operations was beyond the scope of the thesis. We also omitted the anchors and lines because their complexity is more advanced training than we wanted to provide the subjects as well as adding them would have made the interface much more difficult for the user to operate.

We used Figure 4 as the model for this app, as it is simple and shows the way of thinking that we wanted to train to. The simplicity of this figure also meant that by using it as a model, we could build a simple 2D application that trains users in using these forces in the correct way by showing them the actual vectors.

2. Prototype

The MOVES programming team at NPS created a prototype for this trainer that could be used to build up and eventually test. They built a mobile application using the Unity game engine that would be a top down view to include a basic ship, engine and rudder controls, and visual vectors showing the effects of the engines and rudder, and vectors showing the movement of the bow, stern, and overall ship's movement vector.

They also were to add the ability for the user to control the wind and current. The initial prototype is shown in Figure 5.

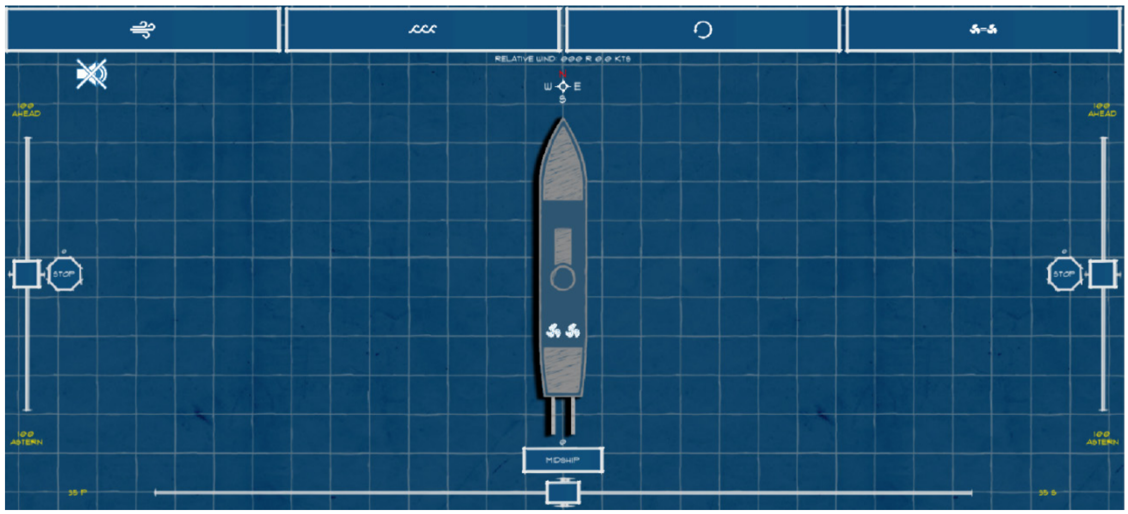


Figure 5. App – MOVES Prototype

The MOVES team built the architecture to be easy to understand and easy to upgrade and add changes. This prototype is built in Unity's 3D mode even though it is a top down, 2D view. This was to make it look as though the ship "pops" out of the screen a little bit and to be more aesthetically pleasing. The overall physics is the same for both Unity 3D and 2D. The arrows for the force vectors are built on the UI canvas, meaning they are not objects in the "scene." This allows easy manipulation and treats them as an overlay to the actual objects in the game.

3. My Efforts

I expanded the prototype to turn it into a valuable training aid. There were multiple things that I focused on to make this happen. First, I wanted to be sure that it "felt" like a ship by adding delay and inertia to the physical model, as the feel is important when driving a ship. I also wanted to expand the UI to give it more functionality without crowding the screen too much, as I was limited on screen space. Having a goal is important in any game or training scenario, so I worked in different pier landing scenarios to provide context and something for the user to try and accomplish. Giving the user a goal, as there was value in just the ship but I wanted to focus on pier work, so I worked in different pier landing scenarios, shown in Figure 6. Finally, there were two important features that I wanted to add to increase the training value based upon feedback after early demonstrations: a simple tug boat and a representation of the moving pivot point, shown in Figure 7.

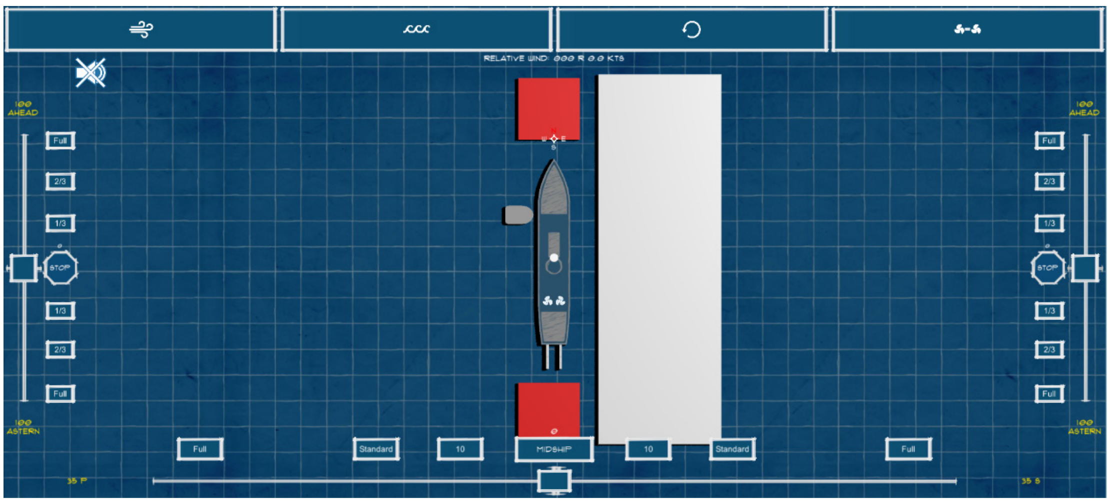


Figure 6. App – Pier

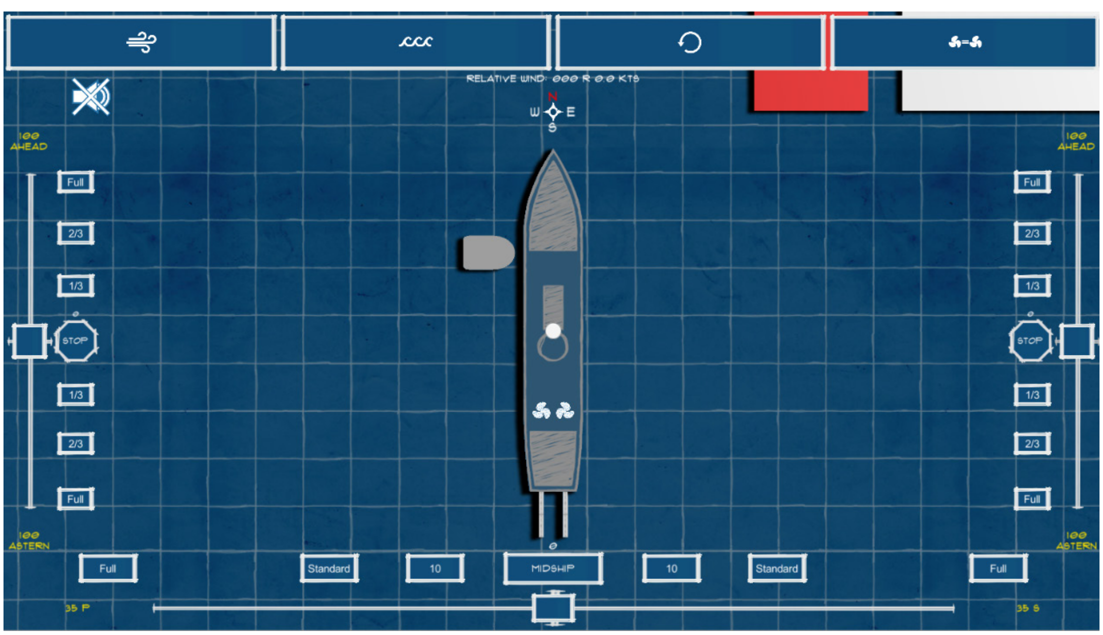


Figure 7. App – Final Version

B. SYSTEM ARCHITECTURE

The overall architecture of the app focus around four things: the ship, the user controls, the forces acting on this ship, and the UI. The ship is a physical object in the environment with forces acting upon it by the user using the UI. The UI has a secondary purpose in that it displays the resultant vectors on the ship, as well as the pivot point. Everything else supports these aspects separately within the scene, these being the background plane and the physical objects (pier, obstacles).

1. Ship

The ship user control for this application is a simple 3D object that is a generic shape of a ship's hull shown in Figure 8. There is no superstructure to it, and it purposefully does not resemble any real world ship in particular. There is simple artwork to add appeal, and representations of the rudders and propellers. Both the rudders and the propellers will move as commands are given to the ship, and that is done with simple animations.

Figure 8. App – Ship

There is a game object called “Ship” in the scene that contains all of the sub objects that are a part of the ship, including the main camera, animated propellers, rudder, the ship hull (the actual 3D object), force reference positions, the ship UI, and finally the tug. The main camera is attached to the ship like this so that it will automatically maintain its position relative to the ship, in this case directly above it looking down at it.

Both the rudders and props are separate from the ship hull because they have separate animator scripts associated with them, with these scripts they also have scriptable objects associated with their spinning rate (props) and angle (rudders). The scriptable objects make it easy to access these values and set them in using scripts throughout the program.

The animated props and rudder are not exact representations of a real ship, and therefore should not be used to demonstrate exactly how either will react with say a DDG. For example, the propellers on the model turn outboard just as they do on a DDG, but they scale exactly with how much speed is ordered. That is not how it works in real life with a CPP system, where the props will turn at the same rate with only the pitch on the propeller changing until about 7 knots. The same is true of the rudders, they scale exactly to how much is ordered, and it is not shown realistically. They are both general representations to help new SWOs understand the concept of what both the props and rudders are doing.

The ship hull is the actual 3D object the user controls. It is a simple model with an imported texture. It also has a box collider attached to it. This defines where other colliders within the scene will hit the ship. In this case a box collider was used for performance reasons.

The reference positions define the specific locations on the ship where the forces are applied, and this is what allows us to simulate how a ship in the real world behaves. These positions are also used to calculate the direction and magnitude of the movement vectors for both the bow and stern. In total there are seven of these reference positions, two being the movement vectors for the bow and stern, four being the thrust positions for the port engine, starboard engine, rudder thrust, and water thrust, and finally a position where the tug thrust is applied.

The ship UI is where all of the visuals attached to the ship reside. These include the vectors for the engines and rudder (yellow arrows), the resultant vectors on the bow, stern, and overall (red), the wind and current vectors (blue), the compass rose, and the pivot point (white circle), all of which can be seen in Figure 9. All of the vectors have an associated scriptable object with a magnitude, and are drawn using a 2D line.

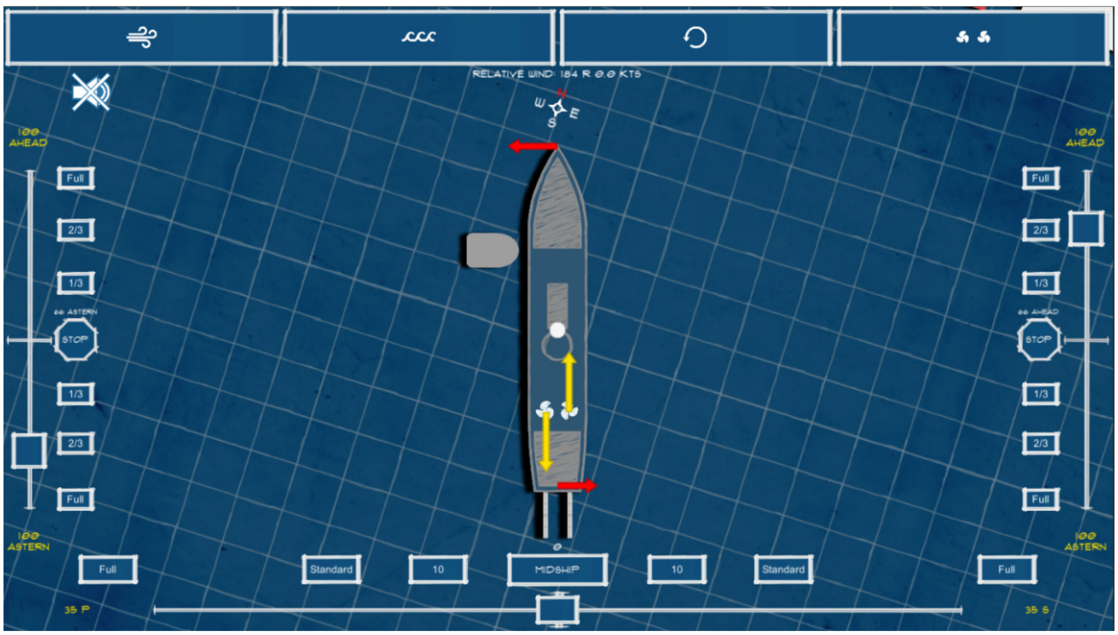


Figure 9. App – All Vectors Shown

The pivot point is represented by a UI slider that runs the length of the ship object with the background "bar" alpha set to 0, making it invisible. It is an approximation on how the pivot point moves as different orders are given. The position of it is based on the current orders to the engines, and whether the ship is moving forward or backwards, or is conducting a twist. The approximation was based upon text from (Barber, 2005) as well as the diagram in Figure 10. It is not meant to be exact, but to give users a general idea on how the pivot point moves as different orders are given to the engines.

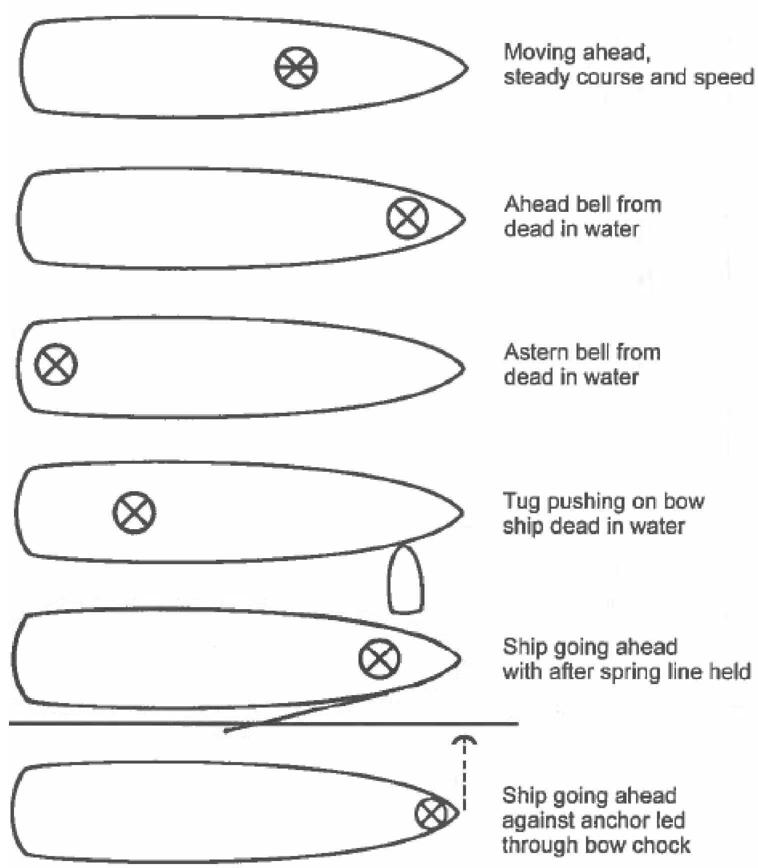


Figure 10. The Moving Pivot Point. Source: Barber (2005).

2. Forces

Forces are applied to the ship utilizing Unity's physics engine in the Ship Simulation script. All of the scriptable objects are passed to the script via the Unity editor, as well as the reference positions. This is also where control values for engine power, rudder power, tug power, wind and current can all be adjusted to alter how the ship handles. Figure 11 shows the values used for all of these variables.

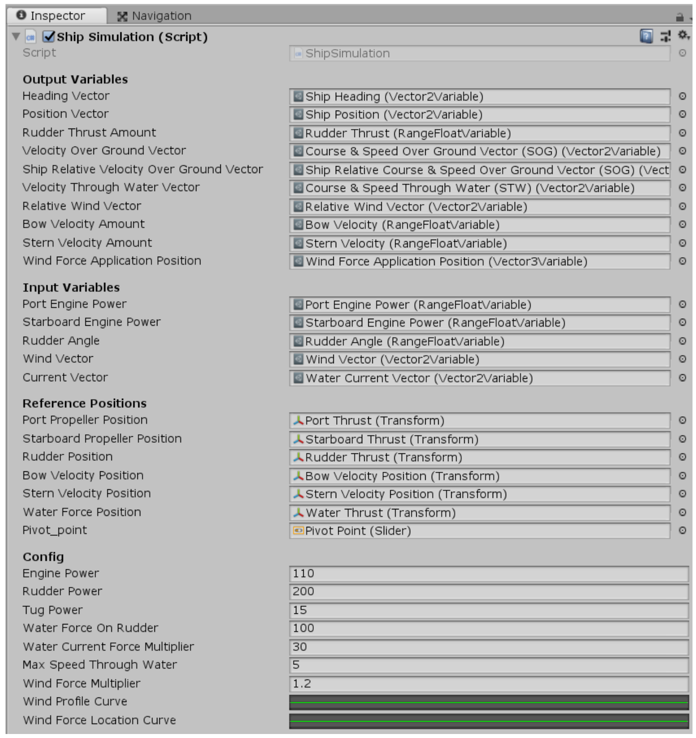


Figure 11. App – Ship Values

The force values used were based on trial and error, and these values provided a reasonable "feel" for the ship, while still keeping everything moving fast enough for a mobile game. It would be easy to adjust these values to make the ship handle like a specific platform, or to make this generic ship respond more realistically with a weightier feel. The code in the background merely applies these forces in Unity's fixed update function, which is called every fixed frame instead of every frame like update and is recommended by Unity for applying physics to a rigidbody (Unity 2018, 2018).

To apply the force, I use rigidbody.ApplyForceAtPosition (vector3 force, vector3 position). This allows us to control exactly where the force is applied on the rigidbody, in this case the ship, which direction relative to the ship it is applied, and much force should be applied. All of these values are scriptable objects passed to the script via the above figure. Using the ApplyForceAtPosition function and defining those specific positions ourselves is what gives us realistic movement for the ship using the rudder, engines and tugs.

3. UI

The MOVES programmers produced the basic UI as well. The general setup was sliders for the port and starboard engine control on the left and right sides of the screen, and a slider at the bottom of the screen for the rudder. Each of these sliders had a button in the middle to set the respective value to 0. There were also four buttons at the top, from left to right, wind, current, reset, and engine coupling toggle.

While these sliders made it easy to control the engines and rudder, it was hard to match opposite orders for the engines. It also was unrealistic to continually change engine or rudder values instantaneously like that. I added in buttons to the sides of the engine sliders for 1/3, 2/3, standard, and full. This enables the user to be able to quickly put on a twist and have no forward or backward movement, critical for maneuvering a ship pier side. It also allows the user to be able make quick, easily repeatable orders, and then use the slider to fine tune the order after the ship starts responding to the initial button press. A typical combination of orders, a 1/3 1/3 twist with the tug pushing ahead is shown in Figure 12

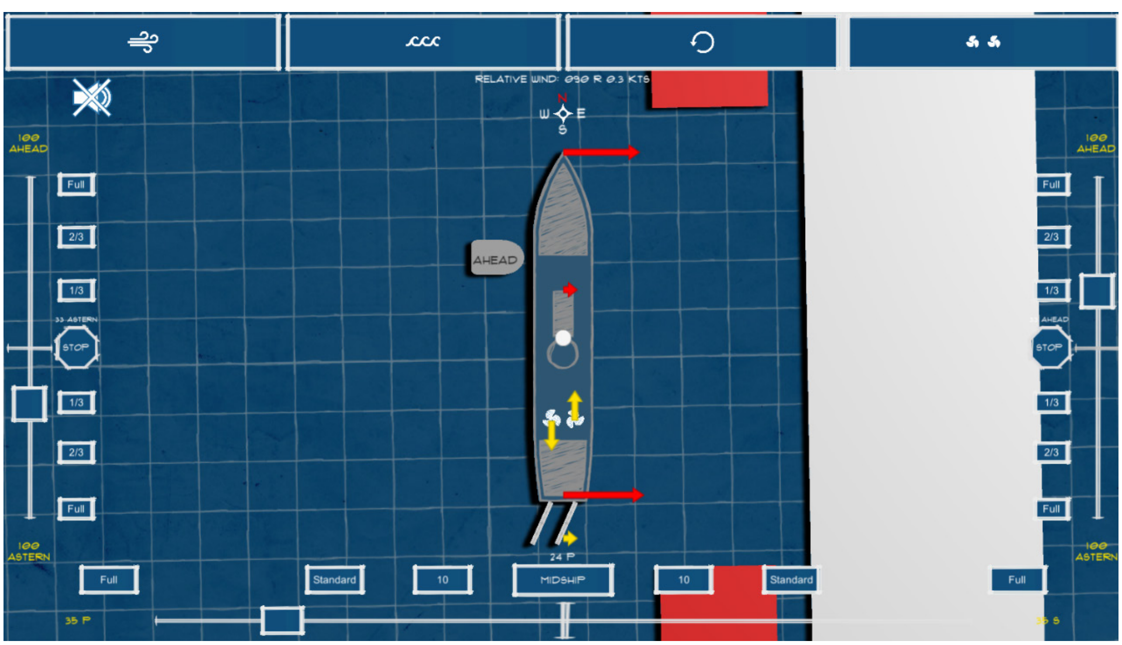


Figure 12. App – 1/3 1/3 Twist

When the wind or current button is pressed, a compass appears on the screen which is shown in Figure 13. For wind, you click on the direction you want the wind to come from, and for current, you click on the direction you want the current to go to, which corresponds to how each of those is normally described in nautical parlance. The user can pick any direction they want for both wind and current, and can make both active at the same time if they wish. As of right now there is no ability to change the speed of the wind or current during a scenario.

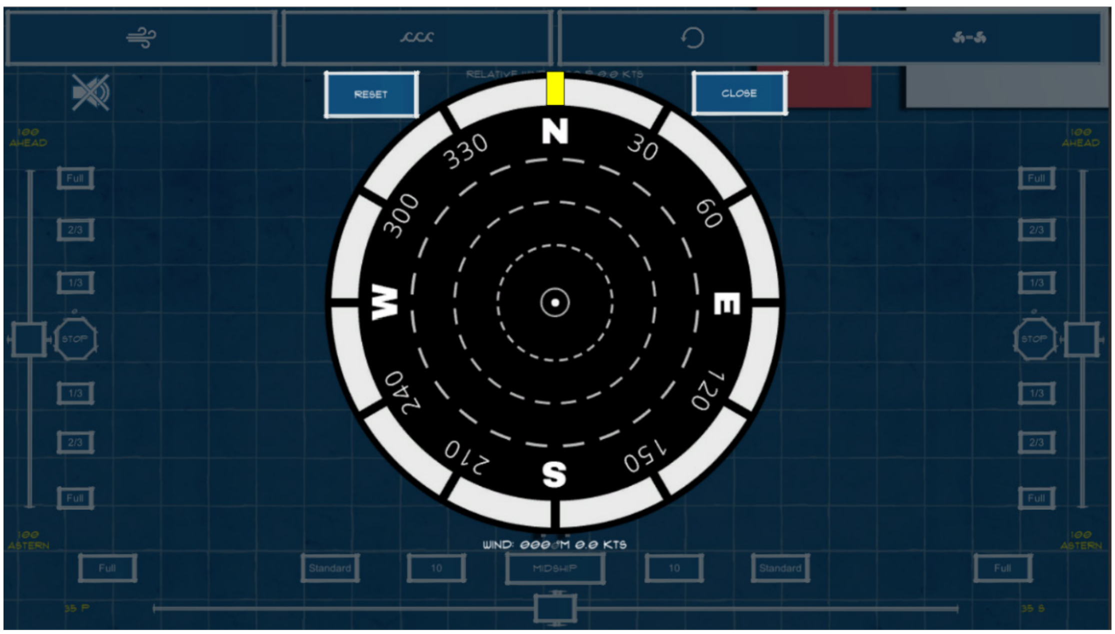


Figure 13. App – Wind/Current Compass

The reset button would reset the simulation whenever pressed in the prototype. I repurposed it to be a main menu button. Now when pressed, it will reset all values and return the user to the main menu that they see when they first start the program. I built this menu to facilitate multiple scenarios within the app. The user can easily jump to different scenarios whenever they wish using the reset button. More detail will be provided regarding the different scenarios present in the app.

Although not technically an “interface,” there are also grid lines laid out across the entire background. Because the ship’s length might cover some of the UI elements as it rotated, I kept the ship always pointing towards the top of the screen. Additionally, the camera always remains over the center of the ship. In order to give the user a sense of the ship’s motion when turning or moving, we added these grid lines to give the user a sense of the ship’s motion.

C. PROGRAMMING AND DEVELOPMENT ENVIRONMENT

We utilized the Unity game engine and editor to develop this app. The app was built in 3D mode and no outside assets were used. All programming for the app was done in the programming language C# using Microsoft’s Visual Studio. Finally, the tug was built using the free, open source 3D modeling software Blender.

D. TRAINING APPROACH AND SCENARIOS

The general idea was to give users simple scenarios to complete to allow them to practice different shiphandling concepts as well as have a goal that mirrors what they would be trying to accomplish in COVE or even in reality. Each scenario was designed to be able to be completed in a few minutes for an adept shiphandler, or longer for a user that requires more practice.

1. Scenes in Unity

A scene in Unity allows you to build an instance of your “game” using all of the code and models in your project. This allows you to create different instances or levels within the game. It also makes it extremely easy to build menus and link the buttons on the menus to different scenes within the game. I used this functionality to create main menu at startup, which contains buttons that link to each scenario within the application shown in Figure 14. The user can exit any scenario at any time to try a different one or restart the scenario they were working on.

Figure 14. App – Main Menu

2. Scenarios

There are three different scenarios in the application. All of them except the first have the same basic goal: land the ship on the pier. All of the scenarios have the same UI, and all can be restarted at any time. The scenarios increase in difficulty from top to bottom, the first scenario being the easiest and the last scenario being the most difficult.

a. Free Play

The first scenario is essentially set in the open ocean shown in Figure 15. There are no obstacles in the scene, the only object is the user's ship. There is also no tug, so the user only controls the ship. It is meant to allow users to familiarize themselves with the UI and the handling of the ship without the tug. There is no goal for the user in this scenario other than to get comfortable with the application and practice different engine and rudder combinations to observe the results.

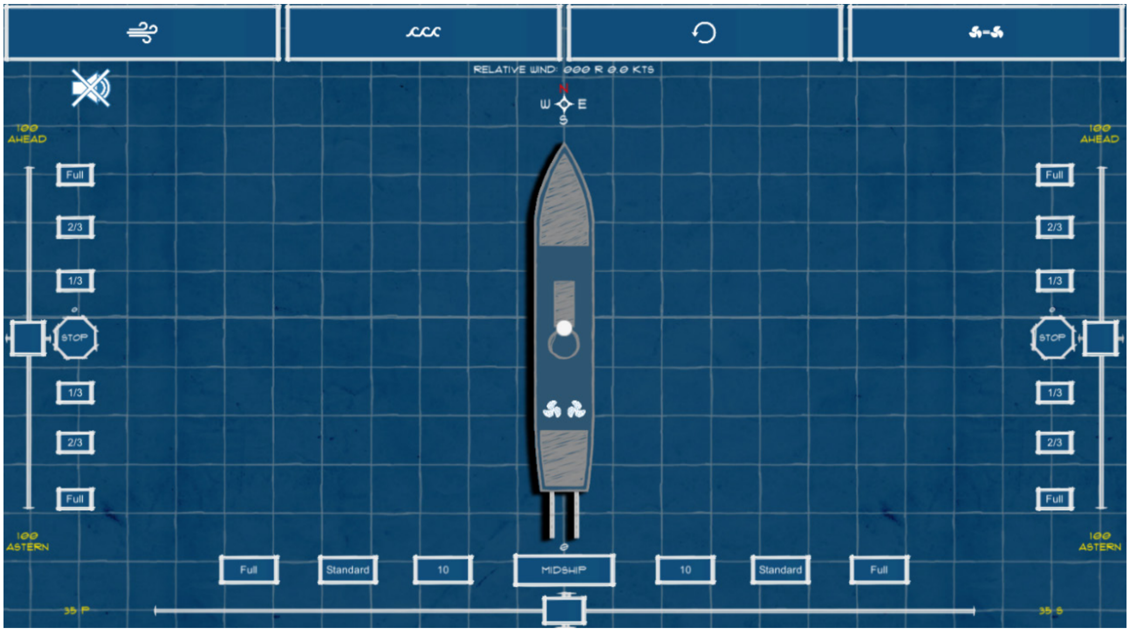


Figure 15. App – Free Play Scenario

b. Restricted Pier

The next scenario is a restricted pier, and it consists of a gray pier, and two red squares shown in Figure 16. The goal of this scenario to land the ship on the pier between the two red squares without hitting them. The red squares are meant to be generic and to simulate some sort of obstacle, whether it be other ships on the pier, some sort of obstruction, or just a small pier. The pier is located up and to the right of the user's ship, and the user is to try and go starboard side to. Another major difference between this scene and the previous scene is the addition of the tug on the port bow. This scenario is designed to be completed in a few minutes, but the user can take as long as they wish to try different ideas and approaches.

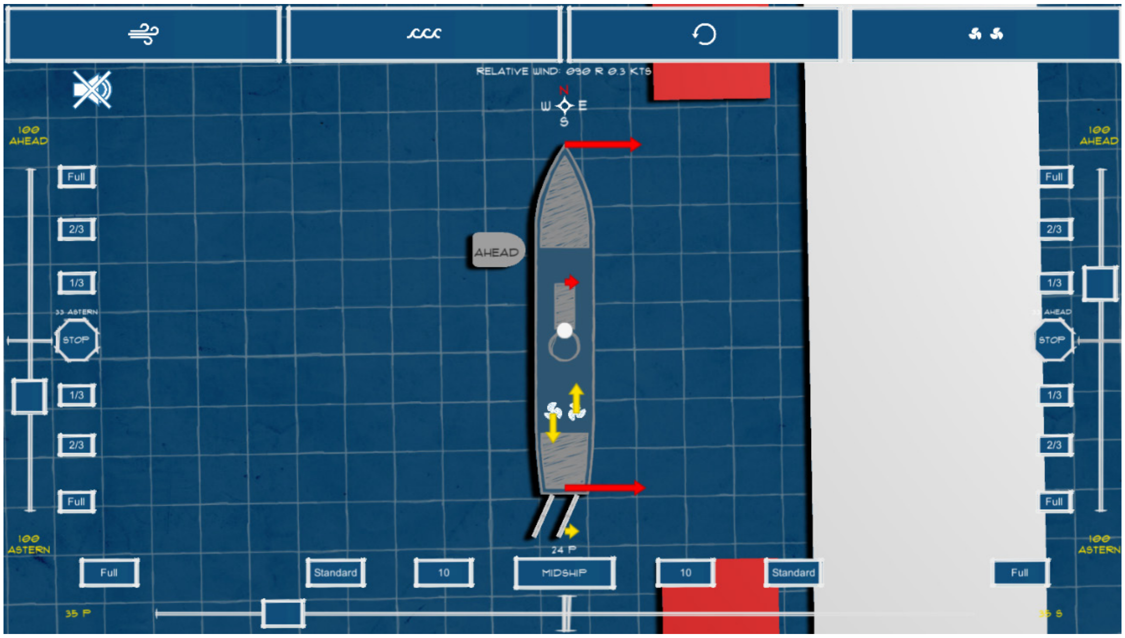


Figure 16. App – Restricted Pier

c. *Turn in Pier*

The final scenario is similar to the restricted pier, as the user must make a landing in between the two red squares, but now they must turn left into a slip first. The turn into the slip is shown in Figure 17. This scenario is meant to take longer than the previous two and is the most difficult, as the slip is narrow and the user must time their turn into it to set themselves up for the landing. Even though this is the most difficult, it can still be done in a few minutes with a skilled user.

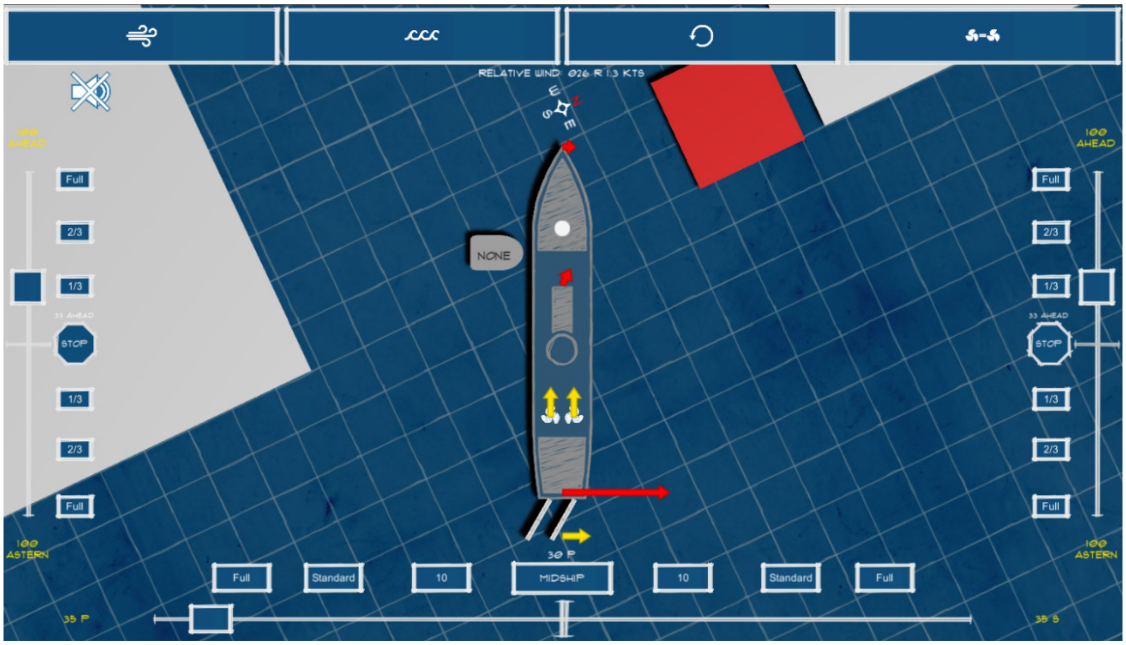


Figure 17. App – Turn in Pier

3. Play for a Few Minutes

All of these scenarios support the same idea, that they should not take long to complete. Instead of having a scenario that takes thirty minutes or more to complete, as the case is in COVE, they can be done in as little as a few minutes. Nothing is hidden, all of the resultant vectors are shown as well as the pivot point, so the user can see how the ship will react instantly. This in addition to scenarios being short allows the user to get multiple tries in the game in the same time it takes to do one run in a full scenario, which will help achieve the idea of a partial task trainer that focuses on the visualization of the forces on the ship and how it reacts.

E. USABILITY OF THE INTERFACE

The most important part of this application was the usability of the interface. This application is meant to be used on a SWOs own time, separate from actual training time. This means that it has to be easy to use, capture their attention, and retain their interest. An overly complicated UI that takes reading a manual will not do this, and they will not use it or continue to use it if it this is the case. On the other end of the spectrum, an overly simple app won't retain their interest or add training value. This means that the application had to be easy to learn, easy to use, interesting, and simple but challenging.

1. Screen Space

Screen space ended up being the biggest factor in deciding what tasks could be trained and what features could be added to support these tasks. The objective of the application was to show resultant forces from different combinations of orders. This, along with screen space, required us to keep the app at low fidelity. As you increase features and training tasks, especially for something as complicated as shiphandling, the controls required and the amount of visual feedback needed goes up very quickly. Even with the simple controls implemented in this app, the screen started to get full very quickly, so the buttons needed to be kept small. Everything ended up being a balance in order to make the app train the tasks required but still have the control necessary to make the trainer useful.

Five years ago, computing power may have been another major constraint. We might have been forced to stick to 2D and a top-down view in order to minimize required computing power to run smoothly on a mobile device. That is rapidly starting to not be the case, as mobile devices have become increasingly capable. Game engines like Unity also do a lot of optimization, and make it easy to put together a 3D simulation. Many games in the mobile marketplace are 3D now, and most mobile devices can handle them without any issues.

2. What is Important?

When designing and implementing a partial task trainer for use on mobile devices, there are a few important factors to keep in mind. With a full size simulator, you need not worry about issues like screen space or user input for control. With COVE for example, the HMD gives you virtually unlimited screen space for visual feedback on what is going on, and you can make it as realistic as you would like. COVE also uses voice for commands, freeing up the screen for the actual simulation. There are also many separate monitors, and stations, from the radar screen to the instructor station showing all of the data.

To implement a trainer on a mobile device, it is critical to identify what specific tasks you with to train, as it would become unwieldy if too many tasks, or too large a task was to be implemented. It is also very important to give a lot of time and thought the controls, or the way the user provides input to the system. With any complex task, there are usually a lot of controllable inputs, and even more outputs that matter to the user. With minimal screen space, it is of upmost importance to keep the controls simple and intuitive, while still providing the required control of the system. I conducted both a training effectiveness test and a user study to get feedback on the user interface and the app overall with junior SWOs at BDOC, and will look at their feedback for the app in the next chapter.

IV. TRAINING EFFECTIVENESS STUDY

A. INTRODUCTION

1. Task

Given that this application was optimized for low speed, pierside movements, it made sense to test using a similar situation. COVE is a high fidelity, realistic simulator that the surface navy already uses for the majority of its training. It also has the advantage that the instructor can set up any scenario desired. COVE also shows the speeds of different parts of the ship in relation to each other to the instructors, allowing them to see exactly what is happening at any given time. To test the effectiveness of this app, we decided to let some subjects use the app before a simple COVE scenario, with a control group going straight into the COVE scenario without using the app first. Using COVE would allow us to measure exactly how the subjects did using existing metrics.

2. Scenario

The COVE scenario we used to test the application was a simple pier landing starboard side too in a DDG 51 with a single tug made up to the port bow. There was no wind or current. The ship would initially have all engines stop, the rudder amidships, and no motion in the middle of the slip 50 yards off the pier, and would be required to "walk" the ship to starboard and make the landing. The performance metrics for making a pier landing at BDOC were used as shown in Figure 18. Objectives 2 and 4 were not used, as there was no wind or current and objective 4 applies more to the turn into the slip.

Approach to Pier (On-Setting Environments)

M C N 1. Did the student maintain a safe distance from the channel buoys, piers and other ships?

M C N 2. Did the student take wind and current into account when docking?

M C N 3. Did the student correctly utilize the Split ship concept to conduct pier work?

M C N 4. Did the student make corrections for various locations of ship pivot point?

M C N 5. Did the student approach the pier at a safe speed?

M C N 6. Did the student land bow first when docking?

M C N 7. Did the student maintain +/- 5 degrees of pier heading when docking?

M C N 8. Did the student land within limits (<0.5 kts all directions within 10 yards of BHS)?

Remediation (If required) – Instructor: **Date:**

Comments:

Figure 18. COVE Grade Sheet for Pier Landing. Source: Basic Division Officer Course, 2018.

B. PARTICIPANTS

1. Junior SWOs at BDOC

Junior SWOs at BDOC were picked to be the subjects for this study. BDOC students are newly commissioned SWOs, most of whom have yet to report to their ship; those who have will have been onboard less than 3 months. Learning shiphandling is a major part of BDOC, and students are given 3 lectures and 9 COVE sessions to learn the basics. Before they begin using COVE, students are given a lecture on standard commands, basic shiphandling, and performing man overboard recoveries. After these 3 lectures, students have 9 COVE sessions scheduled throughout their two months at BDOC. Students also have the option to attend optional practice COVE sessions after classes twice a week.

The COVE simulators at BDOC consist of multiple stations with a HMD, multiple monitors displaying additional information for the students and an instructor station. There are normally 3 students assigned to each station with one instructor per station. The students will then switch off who as the conn as they worked through the scenarios from whatever COVE session they are running through. There were some factors that we had to work past given time constraints.

First, we would have liked to test the students with the app at the very beginning of their class convening, because this is when most of the students are a "blank slate." We were unable to do this however, and had to conduct testing the week before they graduated

BDOC. While it takes much longer than two months and nine COVE sessions to become a competent shiphandler, it did mean that all of the test subjects had a good deal of experience in COVE.

Second, a factor we were unaware of was that depending on when a convening of BDOC begins will influence whether the students have had any time on their ship. For the Fall and Spring classes, most students have already reported to their ship and have had 1–3 months onboard. This does not necessarily mean underway time and time as the conn, but it can and we found a lot of students had spent a little time as the conn on their ship before reporting to BDOC. Classes that convene in the Winter and Spring will mostly have students that have yet to report to their ship, so they are all mostly on a level playing field regarding ship handling. Our testing was conducted in October, so that meant that not only did we test a class that was just about finished with all of their COVE sessions, but we had a class that also had some experience conning in the fleet. These confounds were beyond our control, but by following a disciplined protocol with the participants that were made available to us, we believe that we were able to collect valuable data that is capable of supporting our conclusions.

2. Study Group

The first of the three groups, and a part of the training effectiveness test. The study group subjects used the application for 10–20 minutes prior to conducting the test scenario in COVE. They would then fill out a questionnaire about the app. A BDOC instructor graded subject's performance in COVE, and was not aware who was in the control or study group.

3. Control Group

The second of the three groups, and a part of the training effectiveness test. The control group was used to set a baseline. After they arrived, they went immediately to the COVE station to conduct the COVE scenario. After being graded in the scenario, control group subjects were allowed to use the app to provide feedback about whether they felt it would have helped them as well as general feedback regarding the app.

4. User Study

The user study group was separate from the training effectiveness study. The goal of this group was to get general feedback about the app without subjects having to do the training effectiveness study, which was done during COVE practice time after classes. After a COVE session, volunteers could use the app for as long as they wished, and filled out a questionnaire.

5. Recruiting

Recruiting for both the training effectiveness study and user study was done strictly on a volunteer basis via email. Email addresses for the students were given by officer in charge (OIC) of BDOC.

6. Randomization

Volunteers for the training effectiveness study were randomly selected for the control group and study group using the pseudo-random number generator in Microsoft Excel.

C. METHODOLOGY

1. Training Effectiveness Study Procedures

The goal of the training effectiveness study was to see if there was any meaningful difference in performance in a simple COVE scenario for BDOC students who used the shiphandling trainer application right beforehand. There was a control group that had no access to the app to provide the baseline for BDOC students at that point in BDOC, as they all had the same lectures and COVE training sessions. Subjects had varying lengths of time and experience conning before BDOC.

a. Before

(1) Control Group

When the control group subjects first arrived for the test, they would go straight to a separate room where I would explain the voluntary nature of the study again and inform them that they were a part of the control group. They would then sign the consent form (see appendix), and will out a basic demographic form seen in Figure 19. After filling out these two forms, the subject would go directly next door to the COVE stations where the student would be briefed by the BDOC instructor on their objective.

Subject Number: ____________
Date: ____________

Demographic Student Questionnaire

1. Gender Male Female
2. Age ____________
3. Commissioning Source NROTC OCS USNA Other
4. Did you act as conning officer on: YP cruise Midshipman summer cruise
5. Did you spend any time on your ship before coming reporting to BDOC?
   a. If so how long? (Months) ____________
   b. ROUGH estimate of hours of conning time on ship: ____________
6. Do you play mobile games? Yes No
   a. On what devices do you play? Tablet Phone Both Neither
   b. On average, how long do you play mobile games per day?

   < 30 min 30-59 minutes 1 – 2 hours 2 – 3 hours > 3 hours

Figure 19. Demographic Questionnaire for Training Effectiveness Study

(2) Study Group

The study group would also go straight to a separate room upon arrival where I would notify them that they were a part of the study group. They would sign the consent form, and fill out the same demographic questionnaire. I would then give them the tablet with the application started and on the home screen. I would instruct them to open the restricted pier scenario, and give them a brief tutorial on the controls. I did not give them specific instructions on what to do or tell them what the COVE scenario would consist of. I would let them use the app for 10–20 minutes, and when they were done they would be sent to the COVE station where they would be briefed by the BDOC instructor on their objective.

b. During

Both the control group and the study group were treated identically once sent into COVE. After the BDOC instructor briefed the subjects on the scenario, they would put on the HMD and begin. After starting the scenario, the subjects received no help or guidance until they either collided with something or made a satisfactory landing.

c. After

Following success or failure in the COVE session the control group would be debriefed by the instructor, providing feedback on their performance. The subject was then asked to use the app for 10–20 minutes to allow them to provide general feedback, as well as whether they thought it would have been a help to use the app before the COVE scenario. The study group subjects would fill out the questionnaire immediately following the COVE scenario. The control group subjects filled out the same questionnaire as the study group and user study group. After the subject finished with the questionnaire, they were free to go. While the subject was using the app, the instructor would grade their performance and record the speed over ground(SOG), stern speed, bow speed, and final heading. The instructor also took a picture of the track history for each subject which can be found in the following section.

2. User Study

Participants for the user study were strictly voluntary. Following a scheduled COVE session, students were given the opportunity to use the app and provide feedback. After signing the consent form, I would give students one of the tablets with the app loaded and show them the basic controls and how to navigate the menus. They were then free to use the app for as long as they liked. Once they were done using the app, students were asked to fill out the same questionnaire used for the control and study groups for the training effectiveness study.

D. RESULTS

1. Training Effectiveness

a. Demographics

Participants in this study were all students at BDOC in San Diego, CA. All fourteen of these students were newly commissioned ensigns, with some that had checked into their ships before BDOC. Table 1 shows the demographics collected. Subjects were assigned to either the study group or control group before collecting these demographics. It turned out that the study group ended up having a higher mean time on ship with 1.57 months and a standard deviation of 1.27 compared to the control groups mean of 1 month (0.89). This unsurprisingly led to the mean conning time for the study group being higher at 34.38 hours (48.66) compared to the control group at 21.17 hours (31.88). Another point worth mentioning was that four of the study group participants played mobile games with a mean time per day of 82.25 minutes (66.64) compared to just one control group subject for 30 minutes per day. A more detailed analysis can be found in Chapter IV.

Table 1. Training Effectiveness Study Demographics

	Control				Study			Total		
N	6				8			14		
Gender	2M		4F		3M		5F	5M	9F	
Age(years)	23.5 (2.74 sd)				23.25 (1.83 sd)			23.36 (2.17sd)		
Commissioning Source	2 NROTC	1 OCS	1 OTHER	2 USNA	5 NROTC	3 USNA	7 NROTC	1 OCS	1 OTHER	5 USNA
Time on Ship (months)	1 (0.89 sd)				1.57 (1.27 sd)			1.31 (1.11 sd)		
Conning Time (hours)	21.17 (31.88 sd)				34.38 (48 .66 sd)			28.71 (41.37 sd)		
Play Games	1				4			5		
Devices	1 both				2 phone		2 both	2 phone		3 both
Minutes per Day (min)	30				82.25 (66.64 sd)			71.8 (62.26 sd)		

b. COVE Scenario Results

Table 2 shows the results from the COVE scenario by both the control and study groups. These results were decided by the instructor based on the COVE grade sheet in Figure 17. Although the reasons for failure were varied, most of the time it was a hitting the pier at too high of speed (> 0.5 knots) or landing stern first. The study group appeared to have done better, although the sample size is too small to draw any conclusions from the data.

Table 2. COVE Results

	Control	Study	Total
Successful landing	33% (2)	75% (6)	8
Failure	66% (4)	25% (2)	6

Figure 20 shows the contingency analysis and table of success by group and shows the same data as Table 2. The Pearson p-value in this case is 0.119, since it is greater than 0.05 I cannot say statistically that using the app before the COVE session increased performance. More analysis will be done in Chapter VI.

Figure 20. Contingency Analysis and Table of Success by Group

Figure 21 shows a logistic fit of success by conning time. This table data shows a trend that an increase in conning time before BDOC increases the chance of success, which makes sense. Further analysis will be provided in Chapter VI.

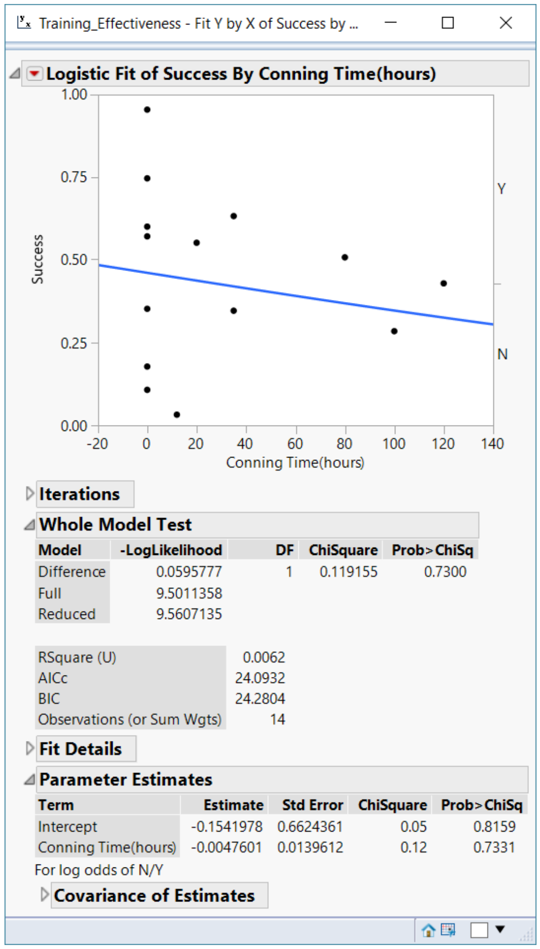


Figure 21. Success by Conning Time

Figure 22 shows a logistic fit of success by minutes played on a mobile device per day. There is a trend upwards that suggests more time spend playing on a device equates to higher performance, but the subject with the highest amount of time spent playing mobile did not succeed in COVE. Again, small sample size precludes any general statements from the data.

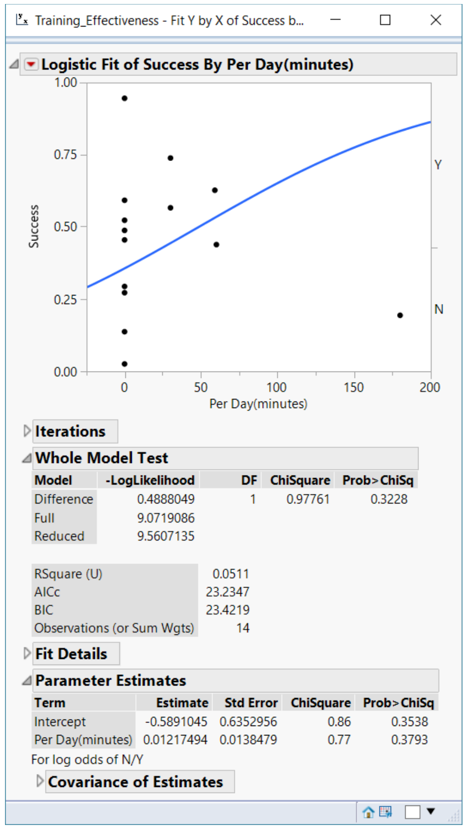


Figure 22. Success by Time Spent Playing Mobile Games

c. *Post Questionnaire*

The list below includes all of the questions that the control and study groups were asked to circle a response. Question 1 answers ranged from not useful, slightly useful, moderately useful, useful, and very useful. Questions 2–7 answers ranged from strongly disagree, disagree, neither agree nor disagree, agree, and strongly agree. For all of these questions, answers were assigned values from 1–5, respectively, for analysis purposes.

1. Please rate how useful you found this application in improving your shiphandling skills:

2. Please rate your agreement with the statement: "The user interface was easy to learn."

3. Please rate your agreement with the statement: “The user interface was easy to use.”

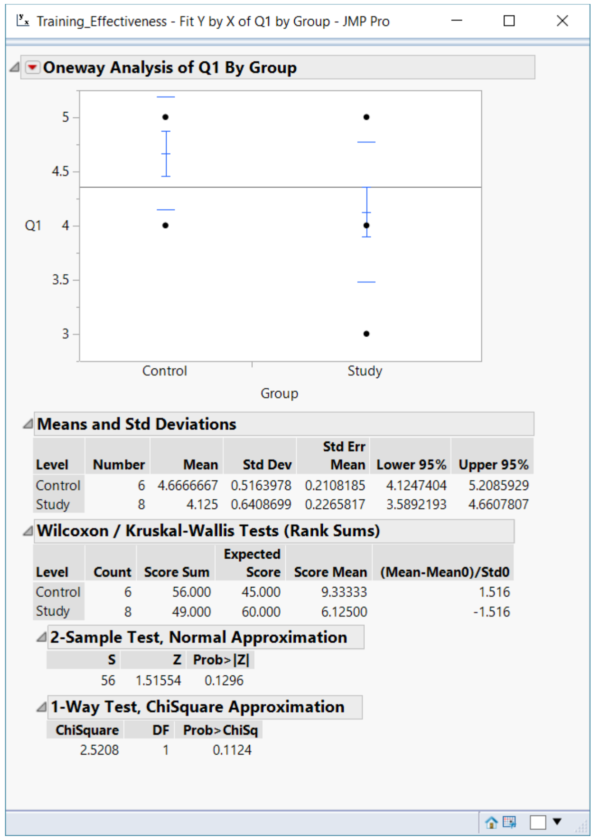
4. “I would use this application after graduating BDOC on my first tour if it were available.”

5. “I would use this application ON MY OWN DEVICE if it were available.”

6. “I think this application would be beneficial to the Surface Warfare community.”

7. “I would like to use mobile application for other types of training.”

Figure 23 is the Wilcoxon ranked sum test for question 1 between the study and control group. The control group answered with a mean of 4.67 while the study group answered with a mean of 4.125. The z score was 1.152 with a probability of 0.1296, meaning that we cannot claim that there is a difference between the control group and study group’s answer to this question.



Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean	Lower 95%	Upper 95%
Control	6	4.6666667	0.5163978	0.2108185	4.1247404	5.2085929
Study	8	4.125	0.6408699	0.2265817	3.5892193	4.6607807

Wilcoxon / Kruskal-Wallis Tests (Rank Sums)

Level	Count	Score Sum	Expected Score	Score Mean	(Mean-Mean0)/Std0
Control	6	56.000	45.000	9.33333	1.516
Study	8	49.000	60.000	6.12500	-1.516

2-Sample Test, Normal Approximation

S	Z	Prob>|Z|
56	1.51554	0.1296

1-Way Test, ChiSquare Approximation

ChiSquare	DF	Prob>ChiSq
2.5208	1	0.1124

Figure 23. Question 1 Wilcoxon Ranked Sum Test

Figure 24 is the Wilcoxon ranked sum test for question 2. The control group answered with a mean of 4.33 and the study group with a mean of 4.625. The z value was 0.089 and probability was 0.92, meaning that we cannot claim that there is a difference between the control group and study group's answer to this question.

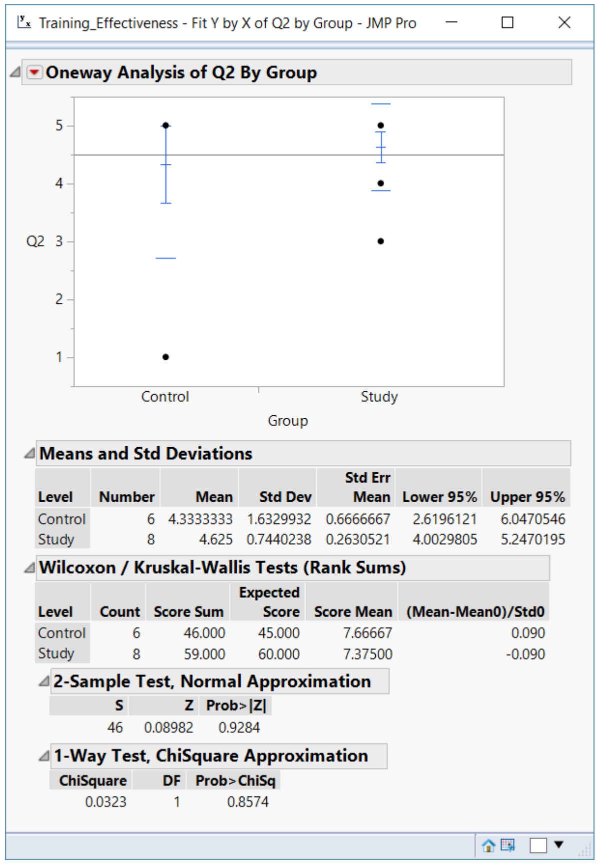
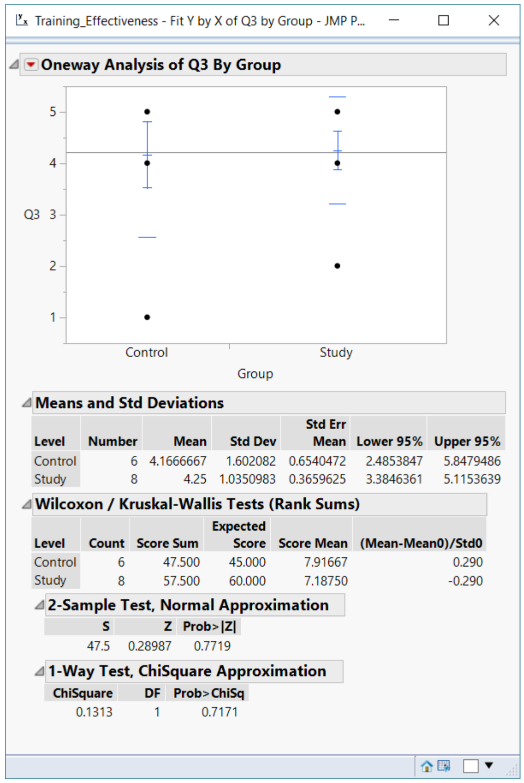


Figure 24. Question 2 Wilcoxon Ranked Sum Test

Figure 25 is the Wilcoxon ranked sum test for question 3. The control group answered with a mean of 4.7 and the study group with 4.25. The z score was 0.29 and probability was 0.77, meaning that we cannot claim that there is a difference between the control group and study group's answer to this question.



Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean	Lower 95%	Upper 95%
Control	6	4.1666667	1.602082	0.6540472	2.4853847	5.8479486
Study	8	4.25	1.0350983	0.3659625	3.3846361	5.1153639

Wilcoxon / Kruskal-Wallis Tests (Rank Sums)

Level	Count	Score Sum	Expected Score	Score Mean	(Mean-Mean0)/Std0
Control	6	47.500	45.000	7.91667	0.290
Study	8	57.500	60.000	7.18750	-0.290

2-Sample Test, Normal Approximation

S	Z	Prob>|Z|
47.5	0.28987	0.7719

1-Way Test, ChiSquare Approximation

ChiSquare	DF	Prob>ChiSq
0.1313	1	0.7171

Figure 25. Question 3 Wilcoxon Ranked Sum Test

Figure 26 is the Wilcoxon ranked sum test for question 4. The control group answered with a mean of 4.33 and the study group with 4.25. The z score was 0.36 and probability was 0.72, meaning that we cannot claim that there is a difference between the control group and study group's answer to this question.

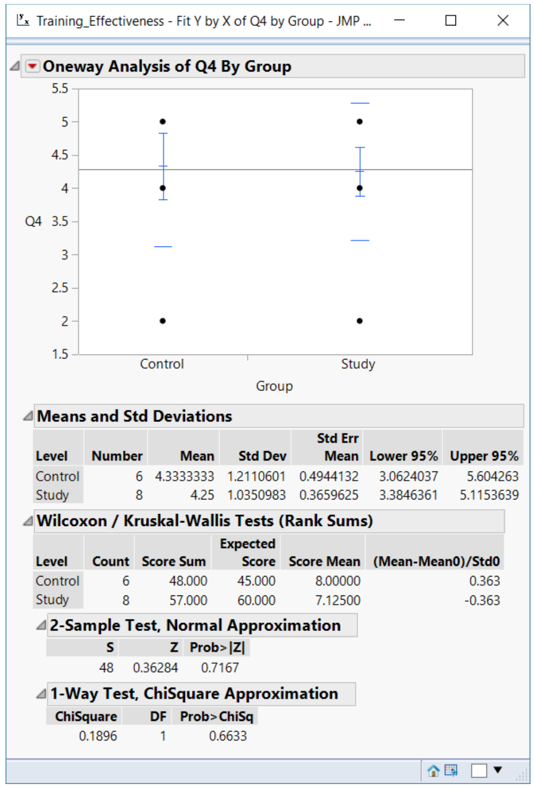
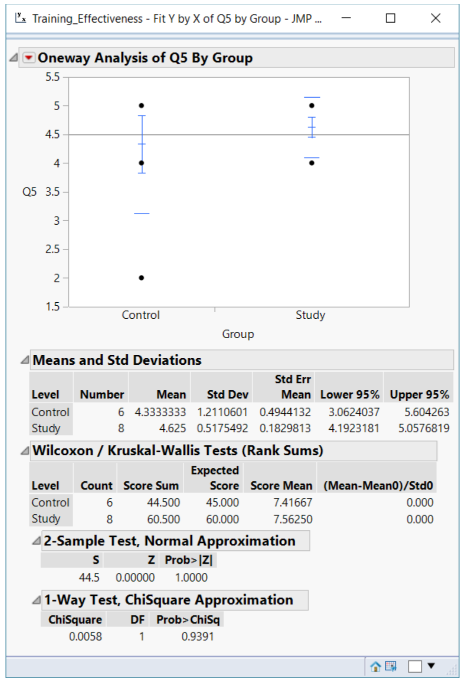


Figure 26. Question 4 Wilcoxon Ranked Sum Test

Figure 27 is the Wilcoxon ranked sum test for question 5. The control group answered with a mean of 4.33 and the study group with 4.625. The z score was 0.0 and probability was 1, meaning that we cannot claim that there is a difference between the control group and study group’s answer to this question.



Level	Number	Mean	Std Dev	Std Err Mean	Lower 95%	Upper 95%
Control	6	4.3333333	1.2110601	0.4944132	3.0624037	5.604263
Study	8	4.625	0.5175492	0.1829813	4.1923181	5.0576819

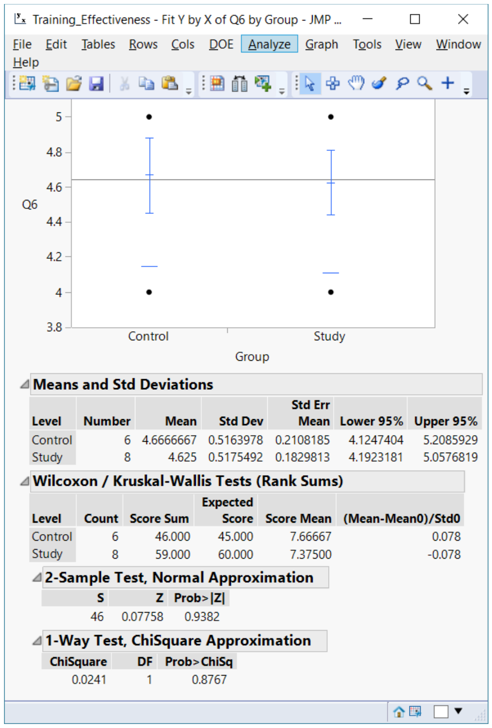
Level	Count	Score Sum	Expected Score	Score Mean	(Mean-Mean0)/Std0
Control	6	44.500	45.000	7.41667	0.000
Study	8	60.500	60.000	7.56250	0.000

S	Z	Prob>|Z|
44.5	0.00000	1.0000

ChiSquare	DF	Prob>ChiSq
0.0058	1	0.9391

Figure 27. Question 5 Wilcoxon Ranked Sum Test

Figure 28 is the Wilcoxon ranked sum test for question 6. The control group answered with a mean of 4.67 and the study group with 4.625. The z score was 0.08 and probability was 0.94, meaning that we cannot claim that there is a difference between the control group and study group’s answer to this question.



Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean	Lower 95%	Upper 95%
Control	6	4.6666667	0.5163978	0.2108185	4.1247404	5.2085929
Study	8	4.625	0.5175492	0.1829813	4.1923181	5.0576819

Wilcoxon / Kruskal-Wallis Tests (Rank Sums)

Level	Count	Score Sum	Expected Score	Score Mean	(Mean-Mean0)/Std0
Control	6	46.000	45.000	7.66667	0.078
Study	8	59.000	60.000	7.37500	-0.078

2-Sample Test, Normal Approximation

S	Z	Prob>|Z|
46	0.07758	0.9382

1-Way Test, ChiSquare Approximation

ChiSquare	DF	Prob>ChiSq
0.0241	1	0.8767

Figure 28. Question 6 Wilcoxon Ranked Sum Test

Figure 29 is the Wilcoxon ranked sum test for question 7. The control group answered with a mean of 4.5 and the study group with 4.75. The z score was -0.85 and probability was 0.39, meaning that we cannot claim that there is a difference between the control group and study group's answer to this question.

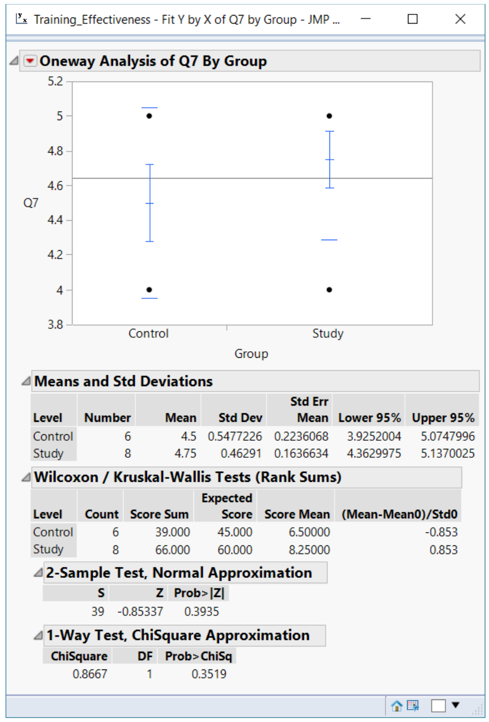


Figure 29. Question 7 Wilcoxon Ranked Sum Test

2. User Study

a. Post Questionnaire

All of the questionnaires were combined to get a sense of the overall attitudes towards the app. Fifty-eight people provided feedback on the app, which includes the 14 from the training effectiveness study and 7 BDOC instructors. Table 3 shows the results from the study. Question 1, which asked users to rate how useful they found the application in improving their ship handling skills had the lowest mean at 4.31. Question 6, which asked if users thought the application would be beneficial to the Surface Warfare community had the highest mean at 4.61. Overall the app was received very well at BDOC, with the average of every question being above 4 with very few outliers.

Table 3. Post Questionnaire Answers

	Q1	Q2	Q3	Q4	Q5	Q6	Q7
5	23	38	32	29	33	34	30
4	30	17	22	22	21	22	22
3	5	1	2	3	1	0	4
2	0	0	1	2	1	0	0
1	0	2	1	0	0	0	0
Mean	4.31	4.53	4.43	4.39	4.53	4.61	4.46
SD	0.63	0.84	0.797	0.76	0.63	0.49	0.63

Another part of the questionnaire were the qualitative questions. They were numbered 1A, 1B, 3A, 3B, 7 and 8. Because these questions allowed the users to write in their answers, it was necessary to group the answers as much as possible, leaving out answers that only had 1–3 responses to keep the tables concise. First, Table 4 shows the responses to question 1.A. The force vectors were by far the most popular. The controls included both engine and rudder control, as well as the tug. The split ship category refers to answers that mentioned the app helping them with the split ship concept. This shows that a wide variety of the features were popular, and users felt different features helped them more than others.

Table 4. Question 1.A – Which Features of the Application Provided the Most Benefit?

	Control	Study	Total
Bow and Stern Vectors	3	7	31
Controls	3	1	17
Split Ship	1	1	12
Pivot Point	2	2	11
Top Down View	1	2	6
Gridlines	1	1	5
Given Scenarios	0	1	4

Table 5 shows the answers to question 1.B. While there was once again a wide variety, there were some features that the users were more interested in. Almost all of these happened to be fixes to current features instead of new ones. The zoom feature would allow the user to zoom out with two fingers, but would snap back when released, a lot of users would like to see that improved. A good number of users also felt that the ship in the application did not move realistically enough. This was by design to allow users to complete multiple scenarios in a short amount of time and to teach concepts, but a good amount of users wanted to see the ship handle a little slower and "feel" heavier. Also, there was some interest in added data to the ship and vectors, such as speed over ground. The tug was another part that will be mentioned later as well, in this case users would like to see more speeds available for the tug, not just forward, back, or stop.

Table 5. Question 1.B – What Features Would be Needed for the Application to be Helpful to You?

	Control	Study	Total
Better zoom feature	1	2	15
Realistic ship handling	0	4	14
Visual Data(SOG, bow/stern speed, etc)	2	1	11
Variable tug speeds	2	1	8
Better wind/current	0	0	6
Advanced scenarios	1	1	5
Different POVs	0	1	4

Table 6 shows question 3.A, focusing on the user interface rather than the applications features. The trend was similar to question 1.A, with the controls and vectors as well as the pivot point being popular.

Table 6. Question 3.A – What was Your Favorite UI Feature?

	Control	Study	Total
Engine and rudder controls	3	5	25
Vectors	1	4	14
Overall layout	3	1	11
Pivot point	0	2	6
Simple to learn	0	0	4

Table 7 shows users answers to Question 3.B, which focuses on whether they thought any parts of the UI were difficult to use. The vast majority of answers were no, a lot of people found the layout simple to learn and easy to use as shown in questions 2, 3, and 3.A. There were some components that some users had trouble with that are worth mentioning. First, the controls refer to engine and rudder control, some users found the buttons hard to press, and/or they did not like the additional slider control. The issues with the buttons were probably due to the size of them, which was a balance between usability and keeping the screen clear to actually be able to use the app. Some others had issue with the tug control, which was a simple tap once for ahead, again for back, and once more for stop. This again was to try and save on screen space, but some users found it difficult to use. Finally, some users felt the zoom was difficult due to the snap back feature and the two finger zoom, which sometimes causes users to zoom in or out while they are trying to use two fingers to control both engines.

Table 7. Question 3.B – Were Any Parts of the UI Difficult to Use?

	Control	Study	Total
No	1	1	22
Controls	0	1	10
Tug control	3	2	9
Zoom	1	3	7

Table 8 shows the response to question 8, which asks about scenarios users would like to see in the future. The overall trend was that users were generally interested in all of the special evolutions SWOs must know how to do. Table 8 shows the most popular scenarios requested. This question was asked to inform decisions for future iterations of the application, since these scenarios are outside the scope of this thesis. The pier landing scenario in this application was added to provide some context and an objective for the primary goal of showing the vectors and pivot and how they change.

Table 8. Question 8 – What Scenarios Would You Like to See Added to the Application?

	Control	Study	Total
Transits(harbor, straits, TSS)	2	3	22
UNREP	3	3	18
Contacts/RoR	0	2	12
Environmentals	1	1	6
Man Overboard	0	2	6

Finally, Table 9 shows the results for question 9, which asked about features users would like to see in the future on this application. Once again many of these were outside the scope of this thesis, but provide a good way forward for future iterations of the application. Some of the more frequent answers were already mentioned as features that were there but needed some work, such as variable tug speeds and a better zoom feature. Many users would like to see different ship classes, which is understandable given that when in COVE at BDOC they train on the platform they will be reporting too. This also goes hand in hand with more realistic ship handling, as that is the primary way the differences in ship classes would be seen. The debrief feature with a path history like COVE has would directly support what this application is training to, and would be an invaluable tool if users were able to see where they made a mistake. This feature would be even more interesting and valuable if users were able to look at the replay or path history, and replay the scenario from a specific point in that history.

Table 9. Question 9 – What Features Would You Like to See in the Future for this Application?

	Control	Study	Total
Different ship classes	3	0	11
Realistic Ship handling	1	0	8
Variable tug speeds	0	0	7
Better zoom	0	0	6
Debrief(path history)	0	3	5
Voice control	0	1	5

V. CONCLUSIONS AND RECOMMENDATIONS

A. CONCLUSIONS

1. Training Effectiveness Study

Given the statistics derived from the training effectiveness study, we cannot say that there is statistical evidence that using the application before a session in COVE increases performance, but we believe this may be attributed to the differing levels of experience of our participant population. A study group where all participants had no prior experience, as discussed earlier, may show a different result. Still a trend is clear. Even though the study group performed better, with a success rate of 75% compared to the control groups success rate of 33%, the pearson p-value is 0.119. Additionally, using a one-tailed Fishers exact test, the p-value for the right side, being that using the app increases performance, was 0.156. Given these two p-values from two separate tests, we cannot say definitively that the application improved performance.

This is most likely due to the small sample size combined with the user experience confounds discussed above. While the two tests used are good options for small sample sizes, a population of fourteen is likely to be just too small. The study group did perform better, and we recognize that this could have been caused by a variety of factors. As shown in the demographics, there were some themes that appeared that were out of our control for this test. First, the study group ended up having more time on average on their ship before reporting to BDOC. As said earlier, this tends to happen for BDOC classes in the fall and spring, a fact that we were not aware of. More time on the ship beforehand likely increases time spent conning, which also was the case here. The control group had an average of 1 month onboard their ship with a standard deviation of 0.89, while the study group had average of 1.57 months onboard with a standard deviation of 1.27. Unsurprisingly, this meant that the study group had more time on average conning at 34.38 hours with a standard deviation of 48.66 and the control group had an average of 21.17 hours with a standard deviation of 31.88. This could be one of the reasons that the study group performed better. However, these hours spent conning most likely were not special evolutions like a transit or making a pier landing and were more likely open ocean steaming. The difference of 13 hours of open ocean steaming is unlikely to make a difference in a SWOs ability to land the ship. The line fit in the analysis of success by conning time did trend upwards, suggesting that this time did help.

Another interesting point is that the logistic fit of success by minutes playing mobile games per day had an upward trend that the more minutes spent playing mobile games per day increased performance. Of the 5 subjects that played games on mobile devices, 4 of them were in the study group, so it is also hard to say that playing games on mobile devices had a bearing on success.

Figure 30 shows the track history of a failure by a subject in the control group. As a reminder, they were directed to work the ship to starboard from the middle of the slip to make a landing. As I watched, the subject was in control the entire time and walked the ship the wrong direction until colliding with a ship moored on their port side. As I talked with the subject afterwards, they understood they were supposed to move to starboard, but did not understand why they were unable to do it. Because this subject was in the control group, they were allowed to use the application afterwards to provide feedback. When showing the subject how to use the app, I demonstrated what their orders they made in COVE did to the ship and how it immediately moved it laterally to port. I then showed the orders required move the ship laterally to starboard, and when all the vectors moved from pointing left to the right, I could see the sudden understanding the subject now had. Using the app before might not have made a difference for this subject in particular, but if they had it on their own device and had access for more time, it might have.

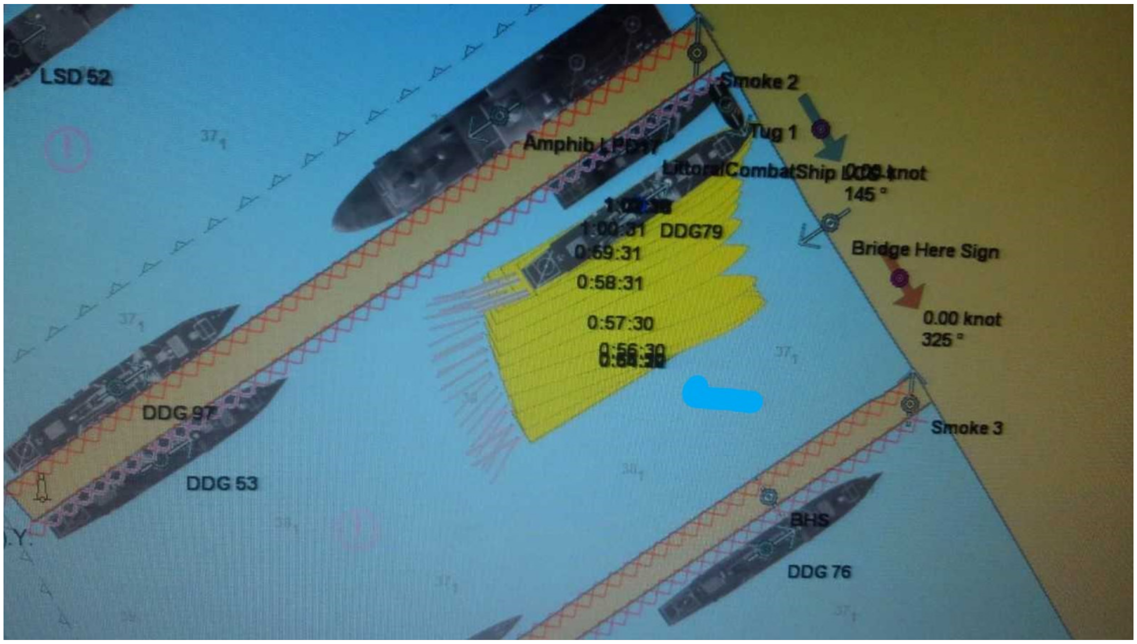


Figure 30. COVE Scenario Failure

While I could not prove that using the application before a COVE scenario increased performance, the numbers suggest that it might. Because the test population ended up being small, it allowed one side to have more time spent conning onboard a ship, and also with N being small enough it could have been that the subjects in the study group were better. I believe that these results warrant further testing of the application with a larger population. BDOC is the perfect place to test this application. In order to prevent some of the demographics, such as time on ship and conning time, possibly influencing the study, conducting another study at BDOC in either the winter or summer at the beginning of the convening would be ideal. This would mean that the subjects likely have not reported to their ship yet, and also have not learned the basics of shiphandling yet, leveling the playing field even more. The application would probably provide more value if the user had access to it for a longer period of time, maybe even on their own device. The final and most important aspect of another study would be to increase the size of the test population.

2. User Study

While proving the effectiveness of the application requires more testing, I can say that this training tool was very popular with both students and instructors at BDOC. The mean for every quantitative answer on the questionnaire ranged from 4.31 to 4.61 out of a maximum of 5. Users thought that it helped improve their shiphandling skills, agreed they would use the application during and after BDOC if available on their own device, and thought that it would provide benefit to the surface warfare community. Users also agreed that they would be interested in more training application on mobile devices.

The most popular features of the app were the visual vectors, the controls, the pivot point, and the overall layout. Users liked that the app showed them what was happening to the bow and stern as they made different orders. They also appreciated the simple design and liked the overall controls as well as the moving pivot point. While there were some things that users did not like or thought could be improved, these were all very specific features like the tug control and zoom functionality. They all on average liked the application overall. The instructor at BDOC who is the primary shiphandling instructor and provides the initial introduction to shiphandling provided the following:

> As an instructor I have limited time and resources to teach students about pivot point, twists and other shiphandling functions. These resources are very limiting and when students cannot conceptualize these functions it greatly hinders their progress throughout the course and their careers. This app would be an invaluable tool for teaching students these concepts before they enter the COVE shiphandling simulators, and during instruction period, as a supplement to COVE. (Anonymous (BDOC Instructor), 2018)

This app is not only a personal training tool, but also a teaching tool, allowing collaboration and quick, real-time examples of concepts that are difficult for new SWOs. There are not many mobile training applications for the surface navy. The first one that comes to mind is the EDIVO app that has practice questions for the Rules of the Road from the actual coast guard test bank. I personally use it and know that a lot of junior officers do as well. It is easy to use and always with you, allowing you to "train" when you are waiting somewhere for something and have five minutes to kill. This app tried to follow that model, that training does not have to occur in a big expensive simulator during working hours. An app like this on SWOs personal devices would allow them to learn and continue to practice the core concepts of shiphandling, and the feedback received shows that there is absolutely interest in something like this.

3. Research Question Answers

Below are our answers to the research questions posed in Chapter I of this thesis.

1. What aspects of shiphandling can be adequately implemented on a mobile device?

    - The basic concepts of controlling a ship and seeing how it reacts with visual vectors can be shown. This showed how the split ship concept works. Showing the moving pivot point was another feature that was simple to implement and added value. Finally, using basic controls I were able to implement a basic pier landing scenario to reinforce and provide context to the vectors and pivot point.

2. What training scenarios in addition to general shiphandling could be implemented on a mobile device?

    - Open-ocean ship handling was easy to implement. I also found that adding in a simple pier landing added a lot of value and did not take anything away from core objectives. Once I added a straight forward pier landing, it made sense to add one where users would be required to turn into the slip.

3. What visual aids would add value to the application?

    - Visual vectors for the engines, rudder, and resultant vectors for the bow, stern, and overall were said to be useful by the users. The pivot point was also well received as well as the gridlines to provide reference for the ship's movement.

- Users would have liked to have more visual information in addition to the vectors, such as speed over ground, speed of the bow/stern, and actual rudder and engine values.

4. Can ready access to a shiphandling trainer improve junior SWO shiphandling knowledge and skills?

    - Access to a shiphandling trainer may improve shiphandling knowledge and skills. Users reported that they thought it did, and 75% of the users who used the application before a simple COVE scenario completed it successfully.

    - More testing with a larger test population is needed to prove it statistically.

5. Given the technical limitations of current mobile devices, what shiphandling tasks can be simulated to support shiphandling training?

    - Graphical limitations were not the issue in simulating shiphandling tasks in support of shiphandling training on a mobile device.

    - The major technical limitation was the amount of screen space available on a mobile device.

6. What is the training effectiveness of using a mobile device for shiphandling?

    - Using a mobile device for shiphandling training may improve shiphandling skills, but more testing is needed.

7. What design features will enhance effectiveness on a mobile device?

    - A simple, easy to learn UI is very important to increasing effectiveness, users must enjoy using it if they are to use it over the other apps on their device.

- Simple, easy to use controls when training something such as shiphandling. For example, users liked the engine and rudder controls on this app, but thought the tug control was difficult. The tug control was certainly simple, but it was not easy to use.
- Ensuring everything on the screen absolutely needs to be there; screen space is the major limitation.

B. RECOMMENDATIONS FOR FUTURE WORK

1. More Testing

More testing with this application is the first recommended step as it may improve shiphandling performance as it. Due to multiple factors, this iteration of testing was not ideal. First, it is recommended to continue with testing at BDOC, as it is a consolidated location for junior SWOs focused on learning how to be a SWO. Testing the winter and summer convening's is ideal, as those students tend to go straight to BDOC from their commissioning source vice reporting to their ship first. Testing a group of students that have access to the app for a longer period would also be recommend, as the subjects for testing in this thesis only used the app for no more than 20 minutes. Finally, a larger test population would be of most value.

2. Update UI

The first recommendation for updates to future iterations of this app would be to address the complaints about the UI. First, users found the zoom feature difficult to use, as it snapped back original position when the fingers were released. User's would like to see a more robust zoom capability. Second, users found the button controls for the engines and rudders not as responsive as they would like. This could be fixed by increasing their size, but the issue of screen space remains. Finally, the tug controls need to be expanded to allow variable speed and the ability to immediately give the order vice cycling through. Some users recommended a pop up control menu or swipe capability for the tug.

3. Add More Training Value

Some suggestions by user would increase the overall training value of this application while still staying within the scope of the objectives.

a. More Visual Data

Many users would have liked to see more data given, mainly speeds to correspond with the vectors on the bow, stern, and overall as well as realistic values for the rudder and engine controls. They were kept generic on purpose for this thesis, but adding these values in would increase overall training value and would allow the app to translate better to the real world.

b. Positive and Negative Feedback

Many users complained that they did not know if they had made a successful landing. This is essentially positive feedback and would absolutely add training value. If a score were included that took into account the speed, angle and time, users would be given more incentive to continue using the app and try to improve their scores. Negative feedback would also be helpful, whether it is hitting the pier too hard or running into an obstacle.

c. Playback Capability

One of the most valuable features of COVE is that it can show a track history of the entire scenario from start to finish. This is an invaluable tool in showing where mistakes were made or where specific orders could have worked better. This would have the same value in this application, it would basically act as a debriefing tool. It could also be expanded on, allowing users to play from a specific point in path history to see what would have happened if they made a different order or an order at a different time.

4. Expansion of Training Tasks and Scenarios

While out of the scope of this thesis, many users would like to see more scenarios add in the future. This thesis wanted to focus on training the basic concepts of shiphandling, the pier landing scenario was added to make the app feel more like a game and to add context to everything. When asked what scenarios user would like to see in the future, transits were the most frequently mentioned and included straights transits, harbor transits, and traffic separation schemes. Almost every other special evolution that we conduct in the surface navy was mentioned, with everything from UNREPS and anchoring to DIVTACS and naval surface fire support. All of these could be built into an application like this one as a partial task trainer, and this user study shows that junior SWOs are interested and want it.

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APPENDIX A. IRB DOCUMENTS

Naval Postgraduate School
Consent to Participate in Research

Introduction. You are invited to participate in a research study entitled Ship Handling Trainer using Personal Devices. The purpose of the research is test and determine whether a simple ship handling training application on a mobile device can improve ship handling performance.

Procedures. You will be asked to complete following tasks:

1. Review and sign consent form – 5 minutes
2. Fill out student questionnaire – 5 minutes
3. Graded COVE session – 15 minutes

Location. The study will take place at BDOC in San Diego CA

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

Voluntary Nature of the Study. Your participation in this study is strictly voluntary. If you choose to participate you can change your mind at any time and withdraw from the study. You will not be penalized in any way or lose any benefits to which you would otherwise be entitled if you choose not to participate in this study or to withdraw. The alternative to participating in the research is to not participate in the research.

Potential Risks and Discomforts. The potential risks of participating in this study are: There is only minimal risk that subject performance data could be exposed, and if it occurred would have minimal impact on subjects lives.

Anticipated Benefits. Anticipated benefits from this study are another method to improve ship handling abilities throughout the surface fleet. You will not directly benefit from your participation in this research.

Compensation for Participation. No tangible compensation will be given.

Access to Performance Data. Your participation will require researcher access to your performance data from the graded COVE session. No past performance data will be collected.

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. No personally identifiable information will be used in the study, and participants will anonymous. Questionnaires and performance data will be kept with the researcher until return to NPS.

If you consent to be quoted anonymously. If you do not agree, then you will be identified broadly by discipline and/or rank, (for example, "fire chief").

☐ I consent to be quoted anonymously in this research study.

☐ I do not consent to be quoted anonymously in this research study.

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

Version #
Date:

the Principal Investigator, Perry McDowell, [redacted] 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, [redacted]

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.

______________________________ _______________
Participant's Signature Date

Version #
Date:

Naval Postgraduate School
Consent to Participate in Research

Introduction. You are invited to participate in a research study entitled Ship Handling Trainer using Personal Devices. The purpose of the research is test and determine whether a simple ship handling training application on a mobile device can improve ship handling performance.

Procedures. You will be asked to complete following tasks:

1. Review and sign consent form – 5 minutes
2. Fill out student questionnaire – 5 minutes
3. Use the application– 10-20 minutes
4. Graded COVE session – 15 minutes
5. Fill out post-study questionnaire – 5 minutes

Location. The study will take place at BDOC in San Diego CA

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

Voluntary Nature of the Study. Your participation in this study is strictly voluntary. If you choose to participate you can change your mind at any time and withdraw from the study. You will not be penalized in any way or lose any benefits to which you would otherwise be entitled if you choose not to participate in this study or to withdraw. The alternative to participating in the research is to not participate in the research.

Potential Risks and Discomforts. The potential risks of participating in this study are: There is only minimal risk that subject performance data could be exposed, and if it occurred would have minimal impact on subjects lives.

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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. No personally identifiable information will be used in the study, and participants will anonymous. Questionnaires and performance data will be kept with the researcher until return to NPS.

If you consent to be quoted anonymously. If you do not agree, then you will be identified broadly by discipline and/or rank, (for example, "fire chief").

☐ I consent to be quoted anonymously in this research study.

☐ I do not consent to be quoted anonymously in this research study.

Version #
Date:

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, Perry McDowell, [redacted] 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, [redacted]

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.

____________________________ ______________
Participant's Signature Date

Version #
Date:

Hello,

My name is JJ Stewart and I'm a computer science student at the Naval Postgraduate School in Monterey CA. I am working on my master's thesis, and what we're doing is developing and testing a mobile application for ship handling. The application is essentially a basic game and the point of it is to help SWOs learn and practice the basic concepts of ship handling by showing the pivot point and vectors on the ship.

That is where you come in, we want to see if there is a noticeable difference in student's performance if they use this application before and after runs in COVE. For the study, half of the volunteers will use the application for approximately 10-20 minutes before a short(15 min), graded ship handling scenario in COVE. The half that does not get to use the application will just do the graded COVE simulation, but will get to use the application afterwards to provide feedback. You will not be observed or graded while using the app, so you can feel free to try different things and see how the ship reacts. I will be there in the space to provide support and collect paperwork.

This is volunteer only, your instructors will not know if you declined or not, and this will have no bearing on you here at BDOC or beyond. This is purely academic. The only additional time commitment is that this study will be conducted during the open COVE times following classes on Tuesday(23OCT) and Thursday(25OCT), you will also be asked to fill out two short questionnaires. The total individual time requirement is less than an hour. You will not be identified by name in the study.

If you think this could be of use to the SWO community and want to participate, please reply to [redacted]

Risks associated with this study are minimal. For more information about this study, please contact the principal investigator, Mr. Perry McDowell, by phone at [redacted], or by email at [redacted].

For information about your rights as a research subject or any other concerns, you may contact the Navy Postgraduate School IRB Chair, Dr. Larry Shattuck, [redacted]

Thank you

Subject Number: ____________
Date: ____________

Demographic Student Questionnaire

1. Gender Male Female
2. Age ____________
3. Commissioning Source NROTC OCS USNA Other
4. Did you act as conning officer on: YP cruise Midshipman summer cruise
5. Did you spend any time on your ship before coming reporting to BDOC?
    a. If so how long? (Months) ____________
    b. ROUGH estimate of hours of conning time on ship: ____________
6. Do you play mobile games? Yes No
    a. On what devices do you play? Tablet Phone Both Neither
    b. On average, how long do you play mobile games per day?

< 30 min 30-59 minutes 1 – 2 hours 2 – 3 hours > 3 hours

Post Study Questionnaire

1. Please rate how useful you found this application in improving your shiphandling skills:

Not useful   Slightly useful   Moderately Useful   Useful   Very useful

A. What features of the application provided the most benefit?

B. What features would be needed for the application to be helpful to you?

2. Please rate your agreement with the statement: "The user interface was easy to learn."

Strongly Disagree   Disagree   Neither agree nor disagree   Agree   Strongly Agree

3. Please rate your agreement with the statement: "The user interface was easy to use."

Strongly Disagree   Disagree   Neither agree nor disagree   Agree   Strongly Agree

A. What was your favorite UI feature?

B. Were any parts of the UI difficult to use?

(Ctrl)

Subject Number:
Date:

Please rate your agreement with the statements:

4. "I would use this application after graduating BDOC on my first tour if it were available."

Strongly Disagree   Disagree   Neither agree nor disagree   Agree   Strongly Agree

5. "I would use this application ON MY OWN DEVICE if it were available.

Strongly Disagree   Disagree   Neither agree nor disagree   Agree   Strongly Agree

6. "I think this application would be beneficial to the Surface Warfare community."

Strongly Disagree   Disagree   Neither agree nor disagree   Agree   Strongly Agree

7. "I would like to use mobile applications for other types of training."

Strongly Disagree   Disagree   Neither agree nor disagree   Agree   Strongly Agree

8. What scenarios would you like to see added to the application?

9. What features would you like to see in the future for this application?

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APPENDIX B. DATA.

A. QUESTIONNAIRE ANSWERS

Subject	Q1	Q2	Q3	Q4	Q5	Q6	Q7
1	4	5	4	4	4	4	4
2	5	5	5	5	5	5	5
3	5	4	4	5	5	5	5
4	4	5	5	5	5	5	5
5	5	5	5	5	5	5	5
6	4	5	5	5	5	5	5
7	5	5	5	5	5	5	5
8	5	5	5	4	2	4	4
9	5	1	1	5	5	5	4
10	4	5	5	4	4	4	5
11	3	3	2	2	5	4	5
12	4	5	5	4	4	5	4
13	4	5	4	2	4	4	4
14	4	5	4	5	5	5	5
15	3	4	4	3	4	4	3
16	5	5	5	5	5	5	5
17	4	4	4	5	5	5	5
18	4	4	3	4	4	4	3
19	5	4	4	5	5	5	5
20	4	5	4	4	5	4	4
21	4	5	5				
22	4	5	5	4	5	5	4
23	5	5	5	5	5	5	5
24	4	4	5	5	4	4	4
25	3	4	3	3	4	4	4
26	5	4	4	5	5	5	5
27	4	4	4	4	4	4	5
28	4	4	4	5	5	5	4
29	4	4	4	4	4	4	4
30	4	5	4	5	5	5	5
31	5	5	5	5	5	5	5
32	4	5	5	4	4	5	4
33	3	5	5	5	5	5	5
34	5	5	5	5	5	5	4
35	4	4	4	4	4	4	4
36	4	5	4				

37	5	4	5	5	5	5	5
38	4	5	4	4	4	4	4
39	4	4	4	4	5	4	3
40	4	5	5	4	4	5	4
41	4	4	4	3	3	4	4
42	5	5	5	5	5	5	5
43	5	5	5	4	4	4	5
44	5	5	5	4	4	4	3
45	5	1	5	5	5	5	5
46	4	4	4	4	4	4	4
47	4	5	5	4	4	4	4
48	5	5	5	5	5	5	5
49	4	4	4	4	4	4	4
50	4	5	5	5	5	4	4
51	5	5	5	5	5	5	5
52	5	5	4	5	5	5	5
53	5	5	5	5	5	5	5
54	5	5	5	4	5	5	5
55	4	5	4	5	5	5	5
56	4	5	5	4	4	5	5
57	5	5	5	5	5	5	5
58	3	5	5	4	4	5	4

1A - What features of the application provided the most benefit?					
Total				Study	Control
31	Bow and stern vectors			7	3
17	Controls			1	3
12	Help with split ship			1	1
11	Pivot Point			2	2
6	Top down view			2	1
5	Gridlines			1	1
4	Pier Landing Scenario			1	
2	Fast pace				
1	Overall UI				
1	Zoom out			1	

1B - What features would be needed for the application to be helpful to you							
Total						Study	Control
15	Zoom out feature					2	1
14	more realistic ship handling					4	
11	Visual Data(SOG, Bow/Stern speed, wind speed)					1	2
8	Tug speeds					1	2

6	Environmentals						
5	Advanced scenarios					1	1
4	Different POVs					1	
3	Notification for successful landing						1
3	Other contacts						
3	select ship class						1
2	Sliders						
2	More tugs						2
2	Ships track history					2	
1	Get underway						
1	tug control explanation						
1	Traffic Seperation Scheme						
1	Voice						
1	More obstacles						
1	No						
1	Specific speed/pitch						
1	Tug location						

3A - What was your favorite UI feature					
Total				Study	Control
25	Engine and rudder controls			5	3
14	Vectors			4	1
11	Overall layout			1	3
6	Pivot point			2	
4	Simple to learn				
3	Wind/current				
2	Tug				
2	Tug control			1	
2	Current engine/rudder orders				1
2	Gridlines			1	1
1	No				
1	Visual Rudder				
1	Feel				
1	View from above			1	

3B - Were any parts of the UI difficult to use					
Total				Study	Control
22	No			1	1
10	Controls(sliders)			1	
9	Tug control			2	3
7	Zoom			3	1
3	speed of ship reaction			1	

3B - Were any parts of the UI difficult to use					
2	Wind/Current			1	
1	Back button				
1	Pivot point hard to see				
1	Different color scheme				
1	Tutorial for sliders				
1	Small numbers				1

8 - What scenarios would you like to see added to the application					
Total				Study	Control
22	Transits(harbor, straights, TSS)			3	2
18	UNREPS			3	3
12	Contacts/RoR			2	
6	Environmentals			1	1
6	MOB			2	
3	Pull into slip				
3	Get Underway			1	1
3	Anchoring			1	1
3	DIVTACS				1
3	Buoy Field			2	
2	More platforms				
2	BtB				
2	None				
2	Obstacles(ships)			1	
1	One for subs				
1	Better tug control				
1	Build own scenario				
1	Night				
1	Low vis				
1	UNREP-slide rule				
1	Online with others				
1	Towing			1	
1	NSFS			1	
1	Small Boat Ops			1	
1	Engineering Casualties				1
1	Flight Ops				1
1	Back into slip			1	

9 - What features would you like to see in the future for this application						
Total					Study	Control
11	different ship classes					3
8	Realistic Ship handling					1

9 - What features would you like to see in the future for this application						
7	more tug speeds					
6	Zoom out					
5	Debrief(path history)				3	
5	None				1	
5	Voice				1	
4	More scenarios				2	1
3	Visual data(SOG, bow/stern)					1
2	More obstacles				1	
2	RoR				1	1
1	Back in time feature(correct mistake)					
1	Weather effects					
1	tutorial for app					
1	Back button					
1	Bearing indicator					
1	Radar					
1	Ships on pier					
1	BtB					
1	Notification for successful landing					
1	Order repeatbacks					
1	Venturi effect					
1	Rudder amounts					
1	Game feel				1	
1	Locked features				1	
1	Different POV					1

B. TRAINING EFFECTIVENESS DEMOGRAPHICS

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W
1	Subject	Group	Q1	Q2	Q3	Q4	Q5	Q6	Q7	HDG	BOW	STERN	SOG	Success	Gender	Age	Com Sourc	Conn	Time on Sł	Conning Ti	Play Game	Devices	Per Day(min
2	1	Study	4	5	4	4	4	4	4	57	0.4	0.5	0	Y	F	22	USNA	N	1	35	N	N	0
3	2	Control	5	5	5	5	5	5	5	53	0.2	0.3	0.16	Y	M	23	NROTC	MID	2	80	Y	B	30
4	3	Study	5	4	4	5	5	5	5	54	0.29	0.6	-0.11	N	M	23	NROTC	N	3	100	Y	P	60
5	4	Control	4	5	5	5	5	5	5	N/A	N/A	N/A	N/A	N	F	22	NROTC	N	0	0	N	N	0
6	5	Control	5	5	5	5	5	5	5	N/A	N/A	N/A	N/A	N	F	29	OCS	N	1	0	N	N	0
7	6	Study	4	5	5	5	5	5	5	58	0.3	0.5	0.4	Y	F	22	NROTC	N	3	120	N	N	0
8	7	Study	5	5	5	5	5	5	5	55	0.2	0.2	-0.11	Y	F	25	USNA	N	2	0	N	N	0
9	8	Control	5	5	5	4	2	4	4	56	0.2	0.3	0.1	N	F	22	USNA	MID	1	12	N	N	0
10	9	Control	5	1	1	5	5	5	4	44	0.49	0.71	0.42	N	M	22	OTHER	N	2	35	N	N	0
11	10	Study	4	5	5	4	4	4	5	60	0.12	0.17	0.11	Y	F	22	NROTC	MID	3	0	N	N	0
12	11	Study	3	3	2	2	5	4	5	49	1.19	0.81	-0.09	N	M	27	NROTC	N	0	0	Y	B	180
13	12	Study	4	5	5	4	4	5	4	54.6	0.4	0.3	-0.14	Y	F	22	NROTC	N	2	20	Y	P	59
14	13	Control	4	5	4	2	4	4	4	54.3	0.4	0.3	0.5	Y	F	23	USNA	N	0	0	N	N	0
15	14	Study	4	5	4	5	5	5	5	57	0.05	0.05	-0.14	Y	M	23	USNA	N	0	0	Y	B	30

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