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A FUNCTIONALITY AND COST ASSESSMENT OF MOBILE LEARNING TECHNOLOGY

December 2021

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**A FUNCTIONALITY AND COST ASSESSMENT
OF MOBILE LEARNING TECHNOLOGY**

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Submitted in partial fulfillment of the
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ABSTRACT

One of the most important and complex programs in the U.S. Navy is the training of its service members. The Navy intends to transform the methods used to deliver training to sailors; that effort focuses on the Ready Relevant Learning (RRL) initiative. The objective of this project is to help define functional requirements for mobile learning delivery and a cost-benefit analysis of options for procuring mobile learning technologies. To accomplish that, we designed and organized a set of interviews with instructors in Navy training centers. We also identified the potential advantages and disadvantages of mobile learning technologies and the roadblocks to procurement and implementation. The results of our work are summarized in a decision-support tool that outlines the roadmap to the procurement of mobile learning technologies.

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LIST OF ACRONYMS AND ABBREVIATIONS

CeTAR	Corporate Enterprise Training Activity Resource
CNO	Chief of Naval Operations
DOD	Department of Defense
FOUO	For Official Use Only
GAO	Government Accountability Office
HTML	HyperText Markup Language
ICT	Information Communication Technology
iOS	iPhone Operating System
IRB	Investigational Review Board
ISTE	International Society for Technology in Education
KO	Contracting Officer
LMS	Learning Management System
NATTC	Naval Air Technical Training Center
NAVPLAN	Navigation Plan
NETC	Naval Education and Training Command
NMCI	Navy/Marine Corps Intranet
NPS	Naval Postgraduate School
RRL	Ready Relevant Learning
TAD	Temporary Additional Duty
TAM	Technology Acceptance Model

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I. INTRODUCTION

A. RESEARCH DOMAIN

In the Chief of Naval Operation's NAVPLAN 2021, Admiral Gilday emphasizes the importance of access to educational platforms for sailors. The belief is based on the rationalization that educated sailors provide a competitive advantage over our adversaries (Gilday, 2021). This competitive advantage is achieved through diligent recruitment of United States men and women who are trainable and can be molded into effective naval assets (Naval Education and Training Command, 2021). The future success of naval training heavily relies upon the Ready Relevant Learning (RRL) concept, the ability to deliver the right training at the right time in the right way: "RRL provides timely, relevant training using an agile, multi-path approach to ensure our operators have the knowledge they need on the deck plates to succeed in combat" (Gilday, 2021). The Navy's support of RRL highly depends on its ability to deliver modernized training anytime and anywhere. That concept encompasses several learning environments where mobile technology enables the end user to become trained and educated wherever they are located, whether it is during their deployment at sea, or while they are land based (Naval Education and Training Command, 2021).

NAVPLAN 2021 calls for an expansion of current training capabilities to be more flexible in delivering RRL at any time and place (Gilday, 2021). Use of RRL will keep sailors on the forefront of training needs and provide the Navy an advantage over its competitors with reduce loss in operational capability when sailors are away to the training schoolhouse. RRL can be especially useful given the limited time that exists between the deployment cycles available for sailor to go to a training center and the impact of a reduction in the workforce due to his absence. The prohibitive cost of sending the sailors to attend training courses makes it difficult to keep everyone up to speed on new training needed. Moreover, packing most training upfront might generate decay in knowledge over time. The goal of RRL is to use modernized distributed training using mobile learning technologies to address these issues by making training available closer to the time and place of use and adaptable to operations tempo.

B. RESEARCH PROBLEM AND MOTIVATION

Current operational tempo leaves little time for sailors to keep up to date on numerous training requirements. Nevertheless, training is essential to stay relevant with technology updates and safety procedures required to optimize force effectiveness. For example, sailors who need to be trained on shipboard watch procedures can potentially start training on a new weapons system prior to arriving aboard the ship, which potentially saves the sailor's and command's time. However, current, and traditional practices require sailors to leave their command to attend a specialized training center or involve sailors needing special access to command training rooms with limited capacity. A solution to this problem is to have sailors access training content on mobile devices. These devices would give sailors greater access to training material anytime and anywhere and reduce their time away from workstations. The objective of this research is to identify the functional requirements of Wi-Fi-enabled mobile devices capable of loading and presenting the training content and practices through networked solutions, and to identify the method of procurement. Our motivation is to ensure we take care of our sailors by providing them with the best tools to realize their full potential, readiness, and confidence.

This research aims to identify the mobile learning technologies that will allow Navy training commands to deliver RRL to meet the CNO's vision and a procurement roadmap to identify the best-value solution. The hardware and software options for mobile training are evaluated based on the customer (training center) functional requirements and costs. This project structures a cost benefit analysis for procuring mobile learning delivery technologies that meet the requirements for each type of training, highlighting any potential roadblocks to implementation.

C. RESEARCH QUESTIONS

The following questions are central to the problem and thesis research study:

1. What mobile learning options satisfy the requirements of naval training centers (instructors)?
2. What is the best value option for procurement of mobile learning technologies, based on the pros and cons of each device relative to type of the training?

D. SCOPE

This study examines the functional requirements that must be satisfied by providing sailors who are taking courses in “A” and “C” schools with ready access to mobile learning technologies. We examine the pros and cons of using mobile learning technologies in distributed training by identifying key mobile learning hardware requirements. To that end, we interview and survey training centers to identify requirements and possible obstacles in implementing mobile technology depending on the type or context of training (on shore, offshore). User needs and cyber security are also an important aspect of acquiring the appropriate technology to support mobile learning, however this is addressed in detail by a separate research group and will not be covered in this thesis research.

E. METHODOLOGY

To answer the research study questions central to this study, we reviewed the Navy training background, literature and other resources that address the Navy’s aspirations of adopting mobile learning technology to conduct RRL. A recent study conducted in 2017 suggested that the methods of delivering classroom training to its sailors were outdated (Davidson, 2017). The same outdated practices may be affecting how sailors’ time is utilized by their commands, and how that level of utilization hampers their already constrained budget. The research in educational approaches and technology that support them suggest that there are learning institutions such as the University of Poland that successfully adopted mobile learning (Rataj & Wójcik, 2020); those findings can serve as a benchmark and guidance to the Navy for implementation of the same approaches.

After establishing a background that provides context to the problem concerning the existing domain, a literature review explores existing methods of mobile learning delivery. The review forms a basis for developing interview questions. Preferred methods came from the information conducted through interviews with instructors who have been using or are considering using that technology in the future. The interview questions were developed using the best practices in conducting this type of data collection and examples of past interviews reported in peer reviewed articles that focus on mobile learning

technology. Additional data points were derived from technology reviews and market research.

Data collected through interviews and survey answers are used to define functional requirements for the hardware, software, and procurement of mobile technologies optimal for mobile learning. We then identified the pros and cons of the functional requirements and looked at the roadblocks for the navy to implement mobile technology. Furthermore, a standardized evaluation method shows a list of requirements to allow comparison and selection of the options such as functional, technical, user experience, and resource use. The results derived from that study allowed us to produce recommendations for mobile learning hardware.

F. THESIS STRUCTURE

Chapter I provides a background of the problem space within a Navy framework and elaborates the challenges that current training practices pose to the training force. Chapter II presents a literature review that explores the requirements and limitations of mobile learning, as well as the experiences of similar efforts that have been conducted in the past. Chapter III elaborates the design and the execution of the interviews with Naval Education and Training Command (NETC) to help us collect the data and evaluate functional requirements. Chapter IV presents the analysis of the data collected. Chapter V discusses our results and presents recommendations for follow-on research.

II. BACKGROUND AND LITERATURE REVIEW

A. INTRODUCTION

This chapter discusses the Navy’s motivation for implementing Ready Relevant Learning. Furthermore, we address student-centered learning, a closely related concept that emphasizes the appropriate technology utilized by end users for the type of courses that have been taught. We also look at the functional requirements defined by past studies and define difference between mobile learning and electronic learning and discuss the diffusion of innovation theory and the adoption of mobile technology to address possible roadblocks such as organizational resistance to change.

B. READY RELEVANT LEARNING

Ready Relevant Learning (RRL), set forth by the CNO in NAVPLAN 2021, is a vital tool to keep today’s sailors up to date and trained on current technology and give the Navy a competitive advantage (2021). RRL is intended to be delivered throughout the Navy’s operational domain from training centers to operational platforms (Figure 1). Sailor 2025 (Figure 2) identifies the Navy’s sailor of the future, which recognizes RRL as a key pillar in aligning Navy learning, continuous career learning, and learning technology (Davidson, 2017). Navy implementation of RRL is focused on giving sailors “timely and targeted training” with the intent of improving sailor performance and enhancing mission readiness (U.S. House of Representatives, 2019; U.S. Government Accountability Office [GAO], 2021). This vision of RRL seeks to modernize the Navy and achieve an advantage by harnessing emerging technology and ensuring the sailors are performing at their best level. Initial delivery for RRL would occur upon entry into the Navy while a sailor is in “A school.” The instruction that follows the basic training (boot camp) is where the recruits begin to specialize for the duties (rating) they will perform in the fleet (U.S. GAO, 2021). Although the initial introduction of RRL will occur during accession into the Navy, the intent is to establish a continuum of learning for sailors where they are able to access the learning content as needed. That type of approach will enhance their readiness by revitalizing learning they have early within their career. RRL will play a large part in the

modernization and readiness of the Navy. However, the challenges of delivering RRL through the right technological devices and supporting infrastructure still needs to be researched and identified (U.S. GAO, 2021).

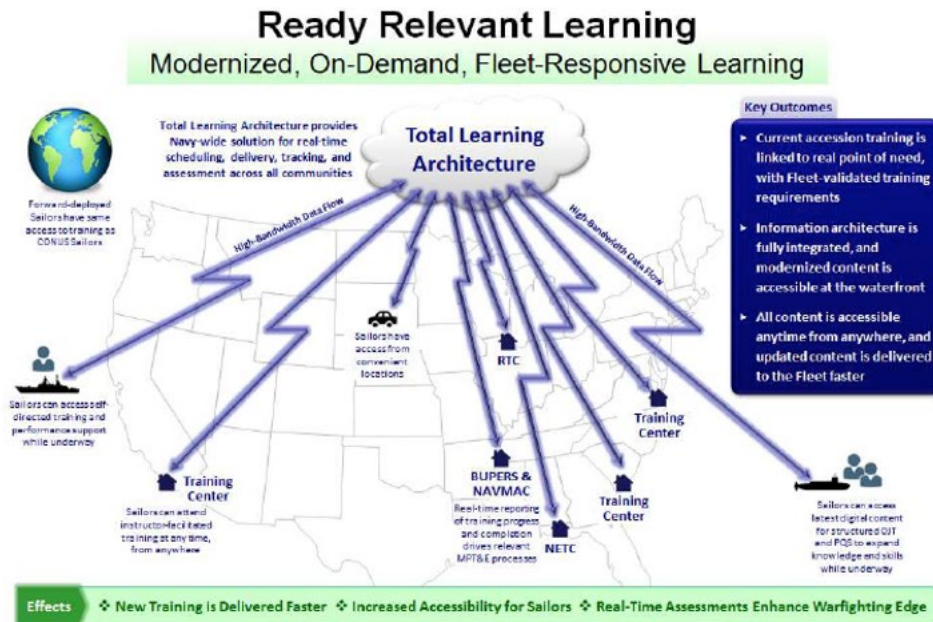


Figure 1. Ready Relevant Learning in the Navy Domain. Source: Davidson (2017).

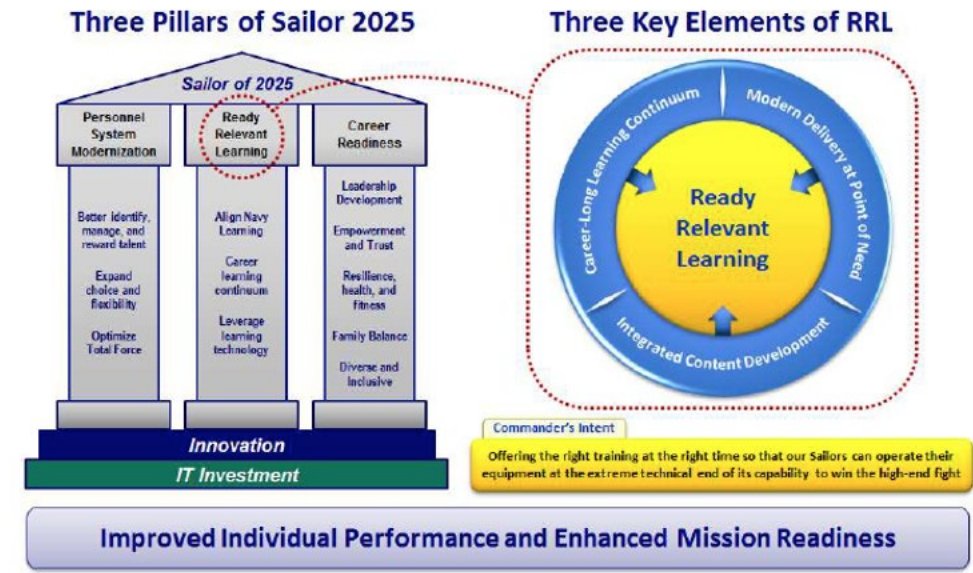


Figure 2. Ready Relevant Learning within Sailor 2025. Davidson (2017).

C. STUDENT-CENTERED LEARNING

For a pro-RRL organization to adopt student-centered learning, the curriculum, pedagogy, and student evaluation must be addressed based on instructors' functional requirements. The idea of student-centered learning involves students transitioning from passive receivers of information to active learners. This transition of learning style to active learning for the Navy must promote career-long learning, modernize the means of receiving education, and the development of course content for sailors (Figure 2) (Davidson, 2017). The technology that students utilize must be applicable to the material the students are learning, and it should also facilitate critical thinking. These steps are important to organizations such as the Navy, because of the student independence that is created to foster lifelong learning (International Society for Technology in Education [ISTE], 2021).

The type of students the Navy educates can benefit from a competency-based education because each student already possesses skills based on their past experiences and education; those elements are taken into consideration by the instructor. Another element of student-centered learning that may be appealing to the Navy is proficient-based instruction. According to Richmond (2014), this is an attractive approach because students

can progress at their own pace once they demonstrate mastery of the required material, thus decreasing the amount of time the student will need for education and training.

However, if student-centered learning is selected by the Navy, training the instructors on how to run a classroom in an open environment will be necessary to make sure that student-centered learning can reach full success. There is also the expectation that some students will be hesitant to try this new learning concept because student-centered learning allows the students to be much more involved in areas of the learning processes that were historically addressed by the instructor (Richmond, 2014). In fact, with student-centered learning, the roles of the students and instructor have changed significantly. The instructor is viewed as a guide who aides the students' learning throughout the educational process (Wright, 2011).

D. FUNCTIONAL REQUIREMENTS

Delivery of RRL through mobile technology and mobile learning will need to meet specific functional requirements to support an ideal student-centered learning model. That includes the use of a spectrum of mobile platforms to facilitate quick and simple interactions between users and learning content. In addition, devices should have the flexibility to view material regardless of display resolutions and add to the learner experience via audio capability. Technical functionality will need to go beyond delivering and facilitating the content and allowing user interaction (voice communication, note taking; Balacheff et al., 2009).

The requirements necessary to implement mobile learning of Navy sailors depend upon available technologies, infrastructure of the location where learning takes place, and the design of the mobile application and its interface. First, the student needs to understand how the learning application operates. For example, the student should understand whether the application requires connectivity or not. Also, the student will need to know what is required of them in terms of how much time they need to allocate to complete training or learning session. That is important because some sessions cannot be stopped once they start, and therefore, the learner needs to allow enough time in their day for completion of that session. However, when determining these parameters, it has been found that many

educators do not have the necessary knowledge to differentiate between the characteristics of each application (Khaddage et al., 2015). The instructors need to understand how the applications they utilize in their class translate to student performance and learning. Therefore, a training that may be more complex will not benefit the students if they are not able to stop and save their progress at any given time. Ultimately, training commands need to evaluate and determine which devices and applications will most benefit the student in accordance with the level of complexity of learning objectives and hardware functionality of the utilized application.

E. MOBILE TECHNOLOGY AND MOBILE LEARNING

1. Mobile Learning vs. Electronic Learning

The success in delivering RRL is connected to the choice and capability of the tools that allow delivery of mobile learning. Mobile learning is defined as “any sort of learning that happens when the learner is not at a fixed, predetermined location, or learning that happens when the learner takes advantage of the learning opportunities offered by mobile technologies” (Klaßen et al., 2013). Mobile learning has benefited the oil and gas industry (Ally et al., 2014), aerospace engineering (Ayuningtyas et al., 2020), as well as the medical field (Zahiri et al., 2018).

Technology development over the years has evolved to allow mobile phones the same computing power that was present in fixed-location computers (i.e., desktop computers and large-scale simulators). Laptops of today afford a greater degree of mobility over desktop computers. In turn, tablet personal computers (tablet PCs) offer greater mobility and storage convenience than laptops. The devices applied to mobile learning have encompassed a wide spectrum to include even personal digital assistants (Traxler, 2005).

As technology progresses, new devices will need to be evaluated to replace older ones. Smartphones are becoming more prevalent in society and present an opportunity to facilitate mobile learning. Table 1 identifies the differences between mobile learning (m-learning) and other traditional forms of learning, such as electronic learning (Mehdipour & Zerehkafi, 2013; Nedungadi & Raman, 2012). The difference between the two types of

learning is reflected in the type of device that is used; e-learning requires laptops and computers while m-learning involves smaller devices like smartphones that are lighter in weight and portable (Munoto et al., 2021; Traxler, 2005). Combining portability and access to the internet allows the most up-to-date training to occur anytime and anywhere.

In conjunction with portability, mobile devices should be able to seamlessly partner with the educational program's learning management system (LMS) to provide a synergistic mobile learning experience. The LMS also should have the ability to deliver the training material through a variety of platforms, and device types should be able to receive and display the training material as the instructors intended. To this effect, it is recommended that technology follows the requirements of the training program rather than a program conforming to specific technology (Rodriguez et al., 2014). In today's Navy, RRL requires access to content that is current and deliverable throughout the diverse operational environment sailors perform under. Emerging mobile device technology with expanding functional capability will enhance mobility of learning.

Table 1. Comparison of Mobile Learning vs. Electronic-Learning. Adapted from Mehdipour and Zerehkafi (2013); Nedungadi and Raman (2012).

m-learning	e-learning
Realistic situation	Simulated situation
Situated learning	Distance learning
Mobile	Computer
Learning anywhere, anytime	Lecture in classroom or internet lab
Spontaneous	Scheduled
Instructor time needed to deliver lecture	Instructor time needed to deliver lectures

When analyzing the potential that mobile learning hardware has, it is important to weight the limitations for each device Mobile learning devices that are easily transported possess limitations such as small screen size, inadequate memory, and short battery life. In

addition to their physical limitations, their software may not have the same capacities as a regular desktop or laptop computer. Therefore, there can be minimal built-in functions, and a limiting ability for additional learning applications (Kukulska-Hulme, 2007). Processing power can be a determining factor and should be capable of supporting iOS and Android app platforms as well as JavaScript-enabled browsers (Nedungadi & Raman, 2012). Also, mobile devices such as smart phones do not have the same capacities as e-learning devices like desktop computers. That can also cause a steeper learning curve for the instructors and users as they need to master operating the application on a new mobile device. As devices become smaller, keyboard functions can hinder the utility of learning. Tablet devices like iPads may offer an advantage over smartphones. Users will need to take these properties into account when completing writing assignments (Vahey & Crawford, 2003). Other properties for consideration for hardware devices include reusability, durability, and maintainability (Keh et al., 2008).

2. Mobile Device User Characteristics

The use of mobile devices to deliver RRL is a viable pathway to fulfill mobile learning, as ownership has increased over the years. According to a Pew 2021 Research Center survey, 85% of U.S. adults own a smartphone. As shown in Table 2, 96% of adults aged 18–29 own a smartphone, while 95% of adults aged 30–49 have a smartphone. Smartphone ownership decreases with the age of the population, 83% for those aged 50–64. Looking at the adult population by education level, smartphone ownership is lower among those with a high school education or less (75%) than those with some college (89%) or graduate college education (93%). Compared to other devices, smartphones have greater ownership among the U.S. population compared to desktop/laptop computers (77%), tablet computers (53%), and e-readers (22%) (Table 3) (Pew Research Center, 2021).

Table 2. Smartphone Ownership among U.S. Adults. Adapted from Pew Research Center (2021).

Demographic of U.S. adults	Smartphone ownership
Ages 18–29	96%
Ages 30–49	95%
Ages 50–64	83%
High school education or less	75%
Some college education	89%
College graduate education	93%

Table 3. Comparison of Device Ownership among U.S. Adults. Adapted from Pew Research Center (2021).

Device	Percent ownership of U.S. adult population
Smartphone	85%
Tablet	53%
Desktop/Laptop computer	77%
E-readers (based on 2016 data)	22%

3. Critical Success Factors for Mobile Learning

Accessibility, ownership, connectivity, integration, and institutional support are critical success factors to use mobile technology for learning (Balacheff et al., 2009). Accessibility is an attribute of mobile learning that needs to be discussed by senior naval leadership; it refers to whether students should use their own mobile devices for learning, or if the Navy should provide mobile device to the student. In addition, students' possibility of utilizing their own mobile devices for learning is an assumption based on smartphone

ownership among U.S. adults (Table 2). Having that in mind, the Navy may prefer to use mobile phones over other mobile learning platforms.

However, institutions have found a drawback to students using their own devices for mobile learning. For example, someone must ensure that the devices used by the students can all run the same applications (Khaddage et al., 2015). There is also a distinct possibility that students may use their mobile device for leisurely surfing the web and social media. However, if the Navy values personal learning, this should not be an issue. The use of devices for entertainment and socializing does not reduce their value for learning. If the Navy does not wish to have students download their learning material, connectivity will also be a critical factor for mobile learning. Connectivity allows the students and instructors the flexibility to send information to themselves both personally, as in a personal email, and professionally, to school or work emails. What is important for instructors and students is the ability to track progress throughout each student's learning experience. That can be satisfied by students having an online journal that tracks their progress or an online course completion tracker that shows the student's mastery of a subject and percent completed. Finally, having a way to train the support staff and determining who will provide technical support is also vital to the success of mobile learning technology. An additional decision will have to determine if the technical support will be internal or contracted.

4. The connection with Learning Management System

Mobile devices that will deliver training must be capable of supporting the intended LMS's content. Whether it be application or web-based, the training content and devices must appeal to a variety of learners and instructors, while encouraging a collaborative learning environment between individuals and groups at any place and time (Rodriguez et al., 2014). Devices must be supportive in projecting the LMS's own functional requirements that include adaptation to a student's learning style and delivery of material across a variety of mediums (simulations and videos), while providing immediate feedback to the learner. Concurrently, the mobile device must be able to support the essential components involved in training such as delivery of learning objectives, lesson plans, and tests. Just as the mobile device is a key factor that links trainers to trainees, the user

interface between mobile device software and user willingness and attention to learn is important. Conversely, the LMS system that will be adopted should consider the most common mobile device operating systems currently available to maximize usage across a diverse user population.

5. Mobile Technology Software

An important link between the user and the mobile device is the operating system software and applications. There are three different types of applications for mobile devices: native mobile applications, hybrid mobile applications, and web mobile applications (Oliveira et al., 2013); the latter are also called web-based applications. However, for this thesis research study, only mobile web applications are considered. The mobile web applications are specific to some of the mobile devices that are considered in this study. The two most common mobile devices that use mobile applications are smartphones and tablets; the applications are accessed through the web browsers such as Safari or Firefox. Using web-based applications is viewed as an advantage for learning institutions because of its inherent lower cost of development. As long as the platform has a web browser, students can use it to access the applications and other resources. Additionally, depending on the complexity of user interface, the applications for different browsers can be minimal, which makes the development and maintenance of those applications much cheaper. It is important to remember that many learning programs started on e-learning platforms such as laptop computers, which may run different applications than smartphones. Another consideration for mobile web app use is its need for network connectivity, in case the application files are not stored locally (on the device) Within the operational environment, Navy units and installations will need to ensure a secure network is available for use. For offline applications, the content must be installed on the mobile device itself. While online applications may be more appealing, the offline applications still provide majority of capabilities needed to organize learning. These capabilities include academic test scores, and scores recorded for the user's own information (Pocatilu & Pocovnicu, 2010).

6. Mobile Technology Security

Barriers to mobile device use lie in the cybersecurity domain and network infrastructure (Schatz et al., 2019). Cybersecurity is an important concern within the Department of Defense (DOD) networks because it affects security of operational planning and execution within a military framework. Hardware and software must conform to DOD requirements while delivering RRL to sailors in multiple operational environments. Naval cyber-security personnel will need to be aware of several risk factors regarding mobile learning and have an ongoing process to assess and mitigate the risk. These risk factors involve confidential information associated with the students. Therefore, cyber-security personnel need to mitigate unauthorized access to course content, student information, and maintain the course's academic integrity (Pocatilu & Pocovnicu, 2010). Organizations that have already incorporated mobile learning conduct audits to ensure the integrity of their mobile learning programs. These organizations can measure the integrity of their programs by identifying potential risk based on their current practices, and data integrity against unauthorized access (Pocatilu & Pocovnicu, 2010). Figure 3 identifies audit process stages currently utilized by the industry. There are several areas where organizations focus their audit of mobile learning devices. These areas include software, servers, mobile learning procedures, and perhaps most importantly, the personnel involved with mobile learning such as students and administrators (Pocatilu & Pocovnicu, 2010).

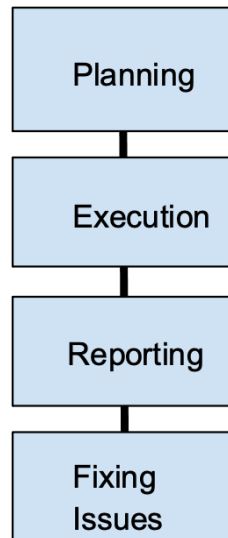


Figure 3. Audit Process Stages for Integrity. Adapted from Pocatilu and Pocovnicu (2010).

7. Testing Applications on Mobile Devices

When identifying potential mobile applications for use, a standard procedure is to conduct software testing; that process helps identify errors in the software before the product reaches its customers. Testing is also crucial to ensure training can be delivered to as many of the various mobile devices as are commercially available, making mobile learning as effective as possible. According to Pocatilu et al. (2010), testing involves a code review during the software development process for applications that will act as a standalone program, independent of network connectivity, or as distributed mobile applications that are web based and require network connectivity. Testing failures could be attributed to hardware incompatibilities, insufficient memory, and poor design of the user interface (2010). Just as careful planning should be placed in the design of the LMS, testing should be considered for the devices that the training program will most likely encounter. Testing of the software product also allows for the adjustments of the code to ensure optimal content delivery acceptable for the device. Prior to implementing training programs through web-based applications, training commands should evaluate and characterize operational characteristics of expected mobile devices that will be used, such as tablets or smartphones. For example, will the learning material be delivered by an iOS

application-based operating system and present itself similarly to an Android-based application? Therefore, the evaluations by the end users can relay back information regarding deficiencies of the smartphone or tablet physical attributes such as small screen size and keyboard. That will ensure consistent training, prevent deterioration of learning content and objectives, and enhance student performance.

F. ADOPTION OF TECHNOLOGY

1. Diffusion of Innovation Theory

Implementation of RRL through mobile technologies is a departure from traditional learning processes within the Navy such as e-learning. Traditional processes involve sailors receiving training early within their career only to employ its use several years or duty stations much later (U.S. GAO, 2021). The introduction and diffusion of an innovative process such as mobile learning will take time to be accepted before its full potential can be realized. The Diffusion of Innovation Theory developed by Everett Rogers (2010) describes the process as occurring over time across communication channels among the members of a social system.

As a new process is adopted, leadership and planners should consider influential parameters that can help facilitate the adoption process. Table 4 describes these parameters adapted from Rogers (2010). The first is to consider the *relative advantage* of the innovation (idea, product, approach, process) over the older. If the adopters perceive an innovation as bringing more benefit over a current solution, the process of adopting innovation will be faster. *Compatibility* is another parameter that relates to how an innovation is consistent with the current solution, standards, and norms. Consider a manufacturing plant; if an innovation requires significant alteration to the overall factory flow, the chances to adopt that innovation will be lessened. Conversely, if a new process is compatible with the existing system, adoption will be easier. A third parameter is *complexity*. The simpler an innovation is, the faster the adoption. *Trialability* is the fourth parameter that suggests an incremental adoption of an innovation over time. Rapid change to a system makes transition more difficult. A gradual transition can assist in addressing problems that arise during implementation and reduce resistance by those with initial

hesitation to the innovation. The fifth parameter of *observability* focuses on promoting successful results with the innovation, i.e., making the adoption of that innovation visible to others. That can influence people resistant to change by reducing doubt of the innovation's effectiveness.

Table 4. Parameters that Influence Adoption. Adapted from Everett Rogers (2010).

Parameter	Effect
Relative Advantage	Greater benefit leads to faster adoption
Compatibility	Greater compatibility with the current system leads to easier adoption
Complexity	Less complexity leads to faster adoption
Trialability	Incremental adoption provides easier adoption of a new system
Observability	Greater visibility of results to other adaptors leads to faster adoption within the system

The combined parameters identified by Rogers (2010) in Table 4 carry the influence over the different stages of adoption, shown in Figure 4 (Magsamen-Conrad & Dillon, 2020). During the adoption process, there will be those who will decide to accept the innovation, while a few will be late-stage adopters. Navy leadership, planners, and instructors should consider these stages by designing programs to integrate innovation. A potential benefit within the military environment is its hierarchical structure. Diffusion and adoption can be further improved by the engagement of leadership and their endorsement of innovation. Unit leadership, together with its chain of command can influence acceptance through decisions, opinions, and support of initiatives for the new technology (Yates, 2013). At the lower levels of chain of command, individuals can act as agents of change and their aids, and additionally affect the adoption. Conversely, leadership and instructors opposed to innovation can impede and negatively influence the diffusion and adoption of innovation.

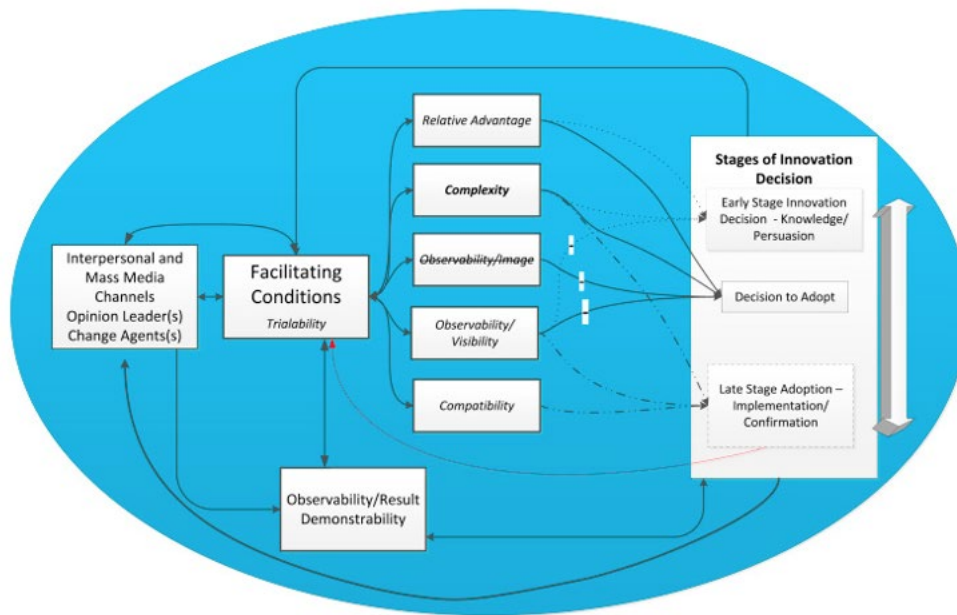


Figure 4. Lifespan Mobile Technology Diffusion Model. Source: Magsamen-Conrad and Dillon (2020).

2. Adoption of Mobile Technology

The Mac Callum et al. (2014) study describing the Technology Acceptance Model (TAM) identifies digital literacy, information communication technology (ICT) anxiety, and ICT technical self-efficacy as challenges related to adoption of new technology. According to the TAM, the users' perception of new technology influences their acceptance. In the first factor of TAM, Navy will need to assess instructors' beliefs that mobile technology will be beneficial to their instruction method. The second factor for the Navy's consideration is discussing which piece of mobile hardware is the easiest for instructors to utilize.

The factors that Mac Callum et al. study found important for instructor buy-in of mobile technology were perceived usefulness, ease of use, instructor literacy of technology, anxiety, and instructor self-efficacy (Figure 5). There is a strong emphasis put on instructor acceptance to gain successful entrance of mobile learning. Instructor acceptance is vital for mobile learning because instructors are the variable that must transition students from formal (non-instructor directed) to informal learning (instructor

based). There is a perception that students may have a deeper understanding in utilizing mobile technology compared to their instructors, but instructor value is present in their skills as educators: they know how to guide students through the learning process, how to sort and critically evaluate the various sources of information, and finally how to evaluate students' skills and knowledge. Therefore, the Navy should assess and improve its instructors' competency level of mobile technology before they engage in work with the students. If the instructor's knowledge is not sufficient, push-back on mobile technology adoption could be expected. Instructors' digital literacy is not only important for buy-in but also for getting their point across to students effectively. Instructors must be able to instill in their students the skills and knowledge required for them to apply when entering the fleet. Society continues to progress to a point where technology is fully integrated in workplaces, and the expectation is that a certain level of technical competency will exist.

The Navy will also have to assess its instructor's level of anxiety throughout the process of mobile learning technology adoption. Instructors who possess a high level of anxiety for mobile learning adoption may also resist this change of instruction. Typically, instructors that have a high level of reservation are fearful that the use of technology will result in a negative learning outcome. Furthermore, instructor's anxiety can be exacerbated if they possess the belief that their students are better capable of using mobile technology than themselves. These notions from instructors can make them question their ability to use mobile technology within the classroom, which is important if the Navy chooses to continue the hybrid method of combining classroom learning with mobile technology.

A great way for the Navy to evaluate the likelihood of instructor buy-in is by measuring their self-efficacy, as elaborated in Mac Callum et al.'s (2014) TAM. Self-efficacy is the instructor's ability to independently adopt mobile technology and integrate it into their instruction. The stronger an instructor's sense of a self-efficacy, the more likely the instructor already has an extensive background in utilizing mobile technology; that also may indicate that their anxiety caused by the introduction of mobile technology is relatively low. In addition, if the instructor has minimal anxiety when transitioning to mobile technology, they are more than likely to view mobile technology as a useful tool that can facilitate learning.

From the results of the ICT study, there is confirmation that digital literacy, ICT anxiety, and ICT self-efficacy are major factors when it comes to receiving instructor buy-in of adopting mobile technology. However, of these three factors, self-efficacy is identified to be the most important (Mac Callum et al., 2014). The Navy will have to be effective in demonstrating the learning benefits of mobile technology while making sure the amount of effort for the instructors' transition is minimal. The better the Navy can sell the concept that mobile technology use is not difficult for instructor, especially for the instructors with low self-efficacy estimate, the higher probability there is for mobile technology adoption. An effective means of demonstrating ease of use of mobile technology is the situation where instructors are able to access the training content on the applicable mobile device remotely, such as from home or while traveling. The more training that is provided to instructors, the more effective and comfortable they will be when it comes time to use mobile technology in their class.

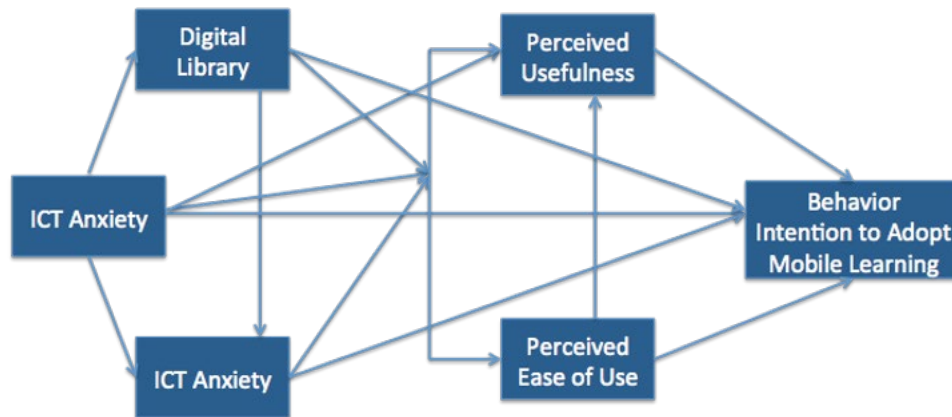


Figure 5. Factors Affecting Instructor Adoption. Adapted from Mac Callum et al. (2014).

3. Procurement and Barriers to Implementation

While most adults in the U.S. own devices that can facilitate mobile learning, not all adults have access. Klaben et al. (2013) conducted a study of 152 students regarding their mobile device preference, which may provide another barrier to students using their own mobile devices for RRL. That study reported that 20 students from their sample of

152 did not own a mobile device in 2013. The rest of the students stated they either owned a smartphone, notebook, netbook, or tablet device (KlaBen et al., 2013). What comes with this variety of hardware are several different operating systems that may or may not all be compatible with learning software. These are important factors to consider when implementing a mobile learning platform and methods of instruction.

III. CUSTOMER STUDY

A. INTRODUCTION

Even though the Navy aspires to update the delivery of training for sailors, the process of implementing RRL is still to be defined. Existing literature about implementing mobile technology within a military domain does not provide enough data to determine requirements. The goal of this research study is to clarify the ideal functional characteristics of mobile technology that would optimize instructors' effectiveness in delivering their courses and identify barriers in acquiring mobile devices for usage. Our expectations are for this information to be utilized by Contracting Officers (KOs) to acquire equipment to best support RRL.

B. RESEARCH GOALS, HYPOTHESIS AND EXPECTATIONS FOR THE STUDY

A goal of this research study is to identify possible options for mobile learning devices. Another goal is to provide the ideal functional requirements for mobile learning devices, with the intent to address the barriers to implementation. We identified pros and cons for each type of mobile learning device and collected data set to formulate a list of recommendations for the functional requirements of this novel form of learning.

We anticipated that the research results will provide evidence that mobile learning technologies can positively influence the future of the Navy's education and training. In addition, we hypothesized that there will be a pushback to adoption of mobile learning technology within the Navy. We also hypothesized that the data would show which mobile learning hardware would be the most beneficial for instructors and what other requirements would be necessary for successful implementation.

C. STUDY DESIGN

While the goal would be to obtain a sample of interview subjects from a representative set of training centers across the Navy ratings, given the time and resources we have available, we collect interviews from two training centers that agreed to

collaborate with us for data collection. Therefore, we report on the issues that surfaced in our data collection. We do not claim that is the absolute set of issues that represents all navy training centers across the Navy. The type of data collection we use allows researchers to have bi-directional discussion and acquire in-depth understanding of the functional requirements best suited to implement mobile technology.

The purpose of the interview questions (Appendix A) was to gain an understanding of training and education command's requirements for mobile technology. The customer focus is primarily based on the needs of naval training instructors and program managers. Gaining an understanding of the types of courses they teach helped in determining which technology should be recommended. These questions provided information regarding the level and type of coursework that the naval education trainings centers conduct, both entry level and advanced. The data collected this way allowed us to compare current approaches to learning with the mobile learning technology option. These questions allowed us also to drill down more specifically to naval education and the organizational needs for mobile learning devices. For example, there were courses that required a certain screen size not optimal for a smart phone while there may be other courses where it was beneficial to have multiple mobile learning devices such as a mobile phone and a tablet.

The data collected in the interviews also provided the researcher with an understanding of how naval education and training organizations are currently delivering training to their students. In addition to current delivery of training, the researcher hoped to learn more about current challenges that the training organizations face; that would help determine how mobile learning technology can assist in overcoming these challenges. The data also helped the researcher define what the naval education and training functional requirements are if these training organizations were to adopt mobile learning technology. In addition, the research gave an understanding of the interaction of course content with mobile technology hardware. For example, will mobile learning hardware require microphone, speaker, and touch screen capabilities, and the ability to take tests and turn in assignments? These functional requirements provided the necessary data for developing mandatory requirements regarding the procurement of mobile technology hardware. In

conjunction, the data provided an understanding of the customer's viewpoint on limitations that specific learning hardware may have in delivering class content.

The existing literature was insufficient in addressing the specifics of the domain that we needed to address in this study. To help identify customer needs and optimize data collection from participants we developed three groups of question (Table 5). The primary group of questions was intended to identify current practices of teaching among Navy institutional teaching organizations. The five questions in this group sought to characterize the course content taught, the current use of technology in delivering that content, and the issues they face in delivering that content. In addition to identifying current practices, our questions were also aimed at highlighting potential needs and uses of mobile devices within a learning environment.

The second group of questions sought to define the characteristics of an ideal mobile device. The four questions within this group focused on defining the ideal physical capabilities of mobile devices in delivering course content, limitations in supporting personal devices, and expected application in the classroom. Providing more insight into the expected application of mobile technology in a teaching environment from the instructor's perspective will help identify a pathway to procuring the optimal device for use at naval training commands.

If the interview session allowed more time with the interviewee, the third group of questions was designed to better define mobile device type of ownership and usage from the course perspective. These series of questions were intended to assess instructor familiarity with mobile technology and willingness to incorporate it in their courses. All questions were expected to help identify the options in procuring and sustaining mobile technology and their application within a military learning environment.

Table 5. Interview Questionnaire Groupings

Question Grouping	Description of Question Grouping
Primary	Identifying current practices of teaching instruction
Secondary	Defining characteristics for an ideal mobile device
Tertiary	Mobile device ownership and usage

D. SUBJECTS

Participants for this research study included instructors, and program managers. Their input aids in identifying the optimal functional requirements needed for procurement and enable better adoption of mobile technology in the classroom environment. No Navy training students were included as part of our research study. Although a student perspective is important in adopting and using mobile technology to deliver RRL, this was covered by another research group.

E. METHODOLOGY AND APPARATUS

The data utilized for this project are obtained from interviewing instructors and program managers from two naval training centers. All study subjects were sought out via email message approved by the unit's chain of command. Initial email contact provided a description of the research project, its intent, along with an electronic copy of the interview questionnaire (Appendix A) and a link to the Microsoft Forms questionnaire link (Appendix B). Members were also invited to participate in a scheduled interview. The variety of options to submit feedback was offered to encourage and maximize participation in the study.

During a four-week period, all data were received through either phone communication, returned email submission of questionnaire responses, or completion of the Microsoft Forms generated questionnaire. Interviews with participants were limited from 30 to 60 minutes.

The responses to questionnaire received from each participant underwent a review process to categorize the information and allow qualitative assessment of the information received. Handwritten and oral responses were evaluated for key words and themes applicable to the groups of question (Table 5). The free form information received via Microsoft Forms was processed similarly. Following characterization all results were compiled onto an Excel spreadsheet along with data collected from other participants to facilitate better analysis.

F. INSTITUTIONAL REVIEW BOARD PROCESS

Our study involved human subjects which meant that we needed to follow the Institutional Review Board (IRB) procedure. After determining the appropriate question type and numbers, they were submitted to the Naval Postgraduate School (NPS) IRB committee for their evaluation. Since we did not ask for personal opinions, all questions submitted to IRB (Appendix A) were determined to not require full IRB documentation and NPS president's approval.

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IV. DATA ANALYSIS

A. SUBJECTS SAMPLE

The data set collected from our study consisted of information from 16 instructors from two training commands. Most of the instructors identified themselves as entry-level instructors, while three instructors identified themselves as curriculum developers.

B. ASSESSING CURRENT PRACTICES

1. Current Locations of Technology Use

The primary group of questions looked at how naval training organizations used technology within their organization to deliver instruction to the students. The data presented in Figure 6 provide the insights into that question: the training organizations currently utilize e-learning in the classroom. The use of technology is static to the classroom area instead of a dynamic range of sites that vary between the home and office. Senior Navy leadership should expect a transitionary period while changing from e-learning to m-learning, and possible pushback from Navy instructors.

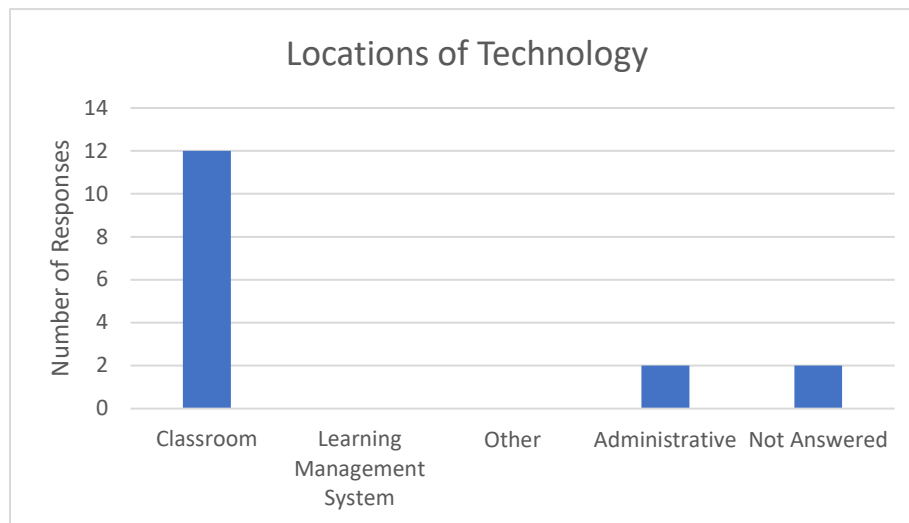


Figure 6. Current Locations of Technology Use (Primary Group-Question 2)

2. Preferences in Type of Mobile Device to Support Training

An effective way to gain buy-in from the instructors and promote the transition of technology use from the classroom to the external environment is to understand the needs of the courses they teach. Figure 7 provides an understanding of what kind of platforms instructors identified as devices that were capable of supporting their organization's teaching approaches.

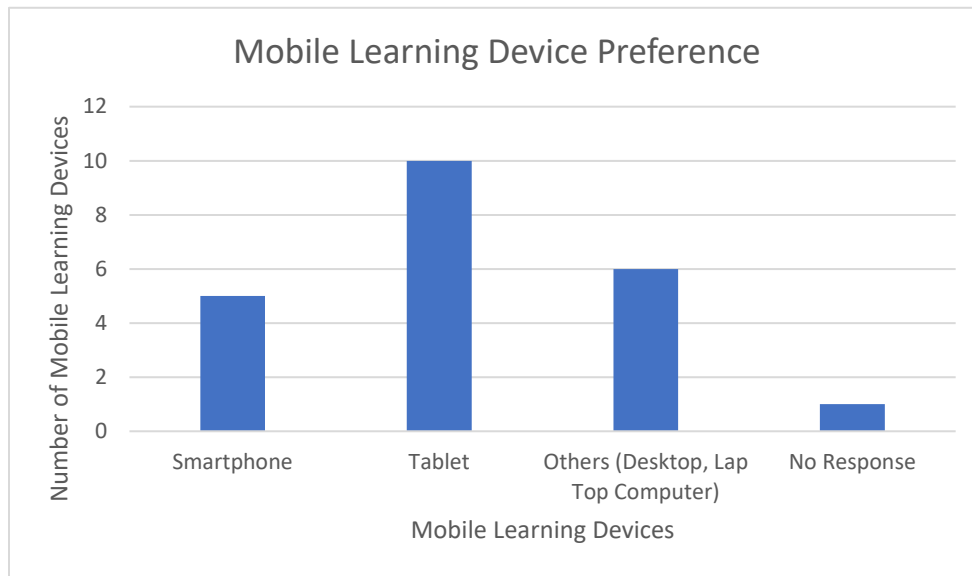


Figure 7. Organizational Device Preference (Primary Group-Question 3)

Instructor's mobile learning preferences for their organization favored hardware such as tablets. This was followed by laptop computers. While desktop computers are not considered mobile technology, laptops have been utilized for both e-learning and m-learning. The main take-away from this chart is an important functional requirement for mobile learning hardware: it is the screen size (display) of the mobile device. Therefore, the favored responses for tablets and laptop computers are justified. A smaller screen size can be a detriment of use and reception by students, indicating a potential drawback to using mobile devices (Kukulska-Hulme, 2007). The organizational preference of tablets

over smartphones supports the idea that from an instructor’s perspective, a larger screen size would have a greater advantage over a smaller one.

3. Resources Used to Support Current Training

Manpower hours identified as the dominate resource most often used to deliver training at the unit (Figure 8). That was followed by a perceived equal distribution of funding going towards IT maintenance, technology training, and funding for devices. In a broader interpretation, this suggests that business practices may need to be adjusted to accommodate a shift towards mobile learning technologies. With the implementation of mobile learning technology, funding will need to be refocused. If the government provides mobile learning hardware, the training commands will need to dedicate more funding for IT maintenance, instructor training, and hardware procurement.

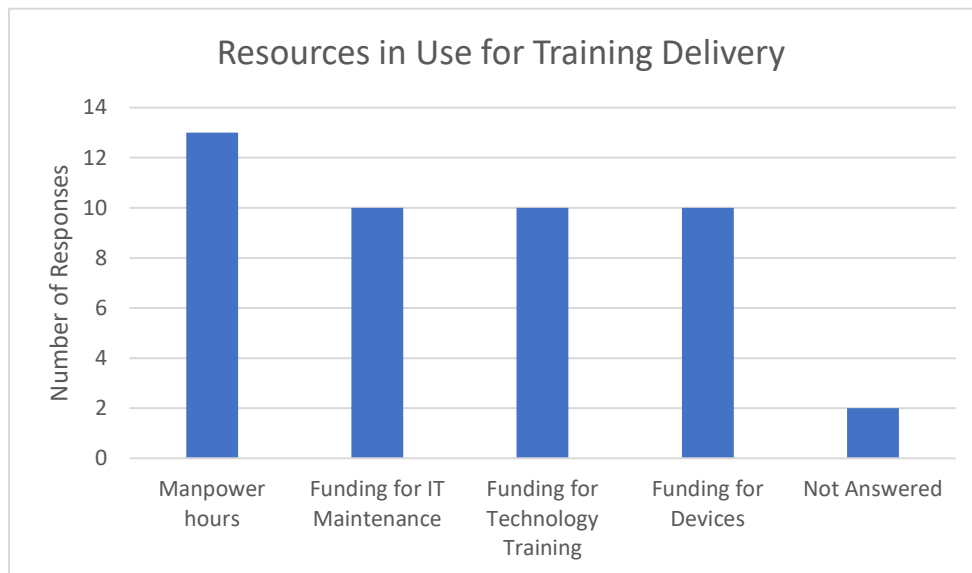


Figure 8. Resources Used to Deliver Current Training (Primary Group-Question 4)

4. Issues that can Prevent Delivery of Training through Mobile Devices

Interviews with participants identified that “Not enough hours to maintain devices” was an issue with current training delivery (Figure 9). That suggests that manpower hours are limited and present a barrier to utilizing current technology to deliver training. When

this barrier is considered, the purchasing command can establish a maintenance contract with the applicable vendor. No “organizational connectivity” and “lack of tech skills” followed as the next key issues. The fourth key issue was resistance to change. The limitation in time to maintain devices also connects to the observed response that there was “Not enough time to accomplish learning objectives in class time.” Time is a limited resource and that should be considered when implementing new technology along with any corresponding change in the curriculum.

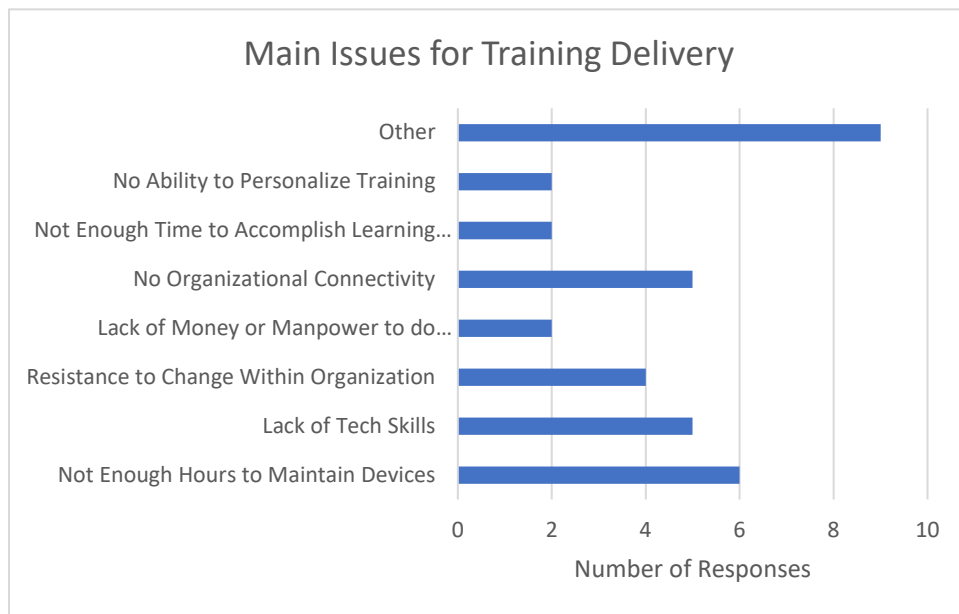


Figure 9. Main Issues for Current Training Delivery (Primary Group-Question 5)

Our interviews with the participants also identified other issues that were not expected (Table 6). The identification of an unreliable internet network within the unit’s LMS, Corporate Enterprise Training Activity Resource (CeTars), carries consideration and requires further investigation. That also presents a possible obstacle to realizing the full capability of mobile training. Future plans that look into utilization of mobile devices should include a reliable network connectivity and access to the host’s LMS. The inability of mobile devices to connect to the local LMS and support training would run counter to Rodriguez et al. (2014), who saw mobile devices and the LMS working in unison to form

and encourage a productive learning and collaborative environment. Having a reliable network would also support the adaptation to technology within an organization. Applying Roger's (2010) Parameters that Influence Adoption (Table 4), discussed in Chapter II, compatibility of mobile devices with the LMS would link to the observability component by instructors and students having positive experiences with mobile learning. Connectivity also ties in with one of Balacheff's (2009) critical factors of a successful use of technology for mobile learning.

Table 6. Other Issues Reported by Interview Participants

Other Issues Reported in Interviews
1. Needing more equipment for relevant coursework. 2. Course material is classified. 3. Unreliable internet connections. 4. Unreliable CeTars web-based training. 5. Current course was designed to work with flash and with flash being no longer supported a lot of the media is no longer available to deliver to students during lessons. 6. Since Adobe flash is no longer supported, many of the motion slides do not work, and those who are responsible for migrating them to HTML-5 are taking a long time. 7. Lack of funding to procure electronic devices (mobile learning hardware).

The issue of connectivity that was mentioned by participants further amplifies the need to possess connectivity across the diverse operational environments. Regular connectivity is necessary to initiate and complete a training objective. The question arises regarding the level of connectivity the organization is willing to accept to meet the need. Table 7 examines the pros and cons of the different levels of network connectivity. When designing a learning program that uses mobile technology, planners will need to consider the existing landscape and consider future expansion of the supporting technical infrastructure.

Table 7. Pros and Cons under Differing Levels of Network Connectivity

Network Connectivity	Pros	Cons
Internet	Figure 1. Provides access to global LMS and a range of collaborative tools if needed Figure 2. Provides access to publicly available web search engines, and secondary information resources (Google, research databases, DOD archives and repositories)	Figure 3. Requires dedicated infrastructure to support network connectivity Figure 4. Requires globally dedicated infrastructure to support storage and management of learning material (LMS) Figure 5. Cybersecurity concerns
Intranet (local network)	Provides access to local LMS and a range of collaborative tools if needed	- Requires local dedicated infrastructure to support network connectivity - Requires local dedicated infrastructure to support storage and management of learning material - Cybersecurity concerns - No access to publicly available secondary information resources (Google, research databases, DOD archives and repositories)
No connectivity	- Once applications and content are downloaded, access to learning material is not restricted by connectivity (anytime/anywhere) - No cybersecurity concerns	- Applications and content must be updated by users - Inhibits access to additional training material if it was not initially downloaded - No access to LMS and collaborative tools - No access to publicly available secondary information resources (Google, research databases, DOD archives and repositories)

C. DEFINING MOBILE TECHNOLOGY CHARACTERISTICS

1. Functional Capabilities for Mobile Devices

If the government proceeds to procure mobile learning hardware, sound output (speakers) and playback of videos and animations would be the two most significant functional requirements in a statement of work based off Figure 10. Balacheff (2009) recommends that mobile learning hardware provide flexibility with an array of capabilities for the end user. As more Navy Education and Training commands that teach different types of courses are interviewed, there is a possibility that additional functional requirements will be identified. For example, if email and instant messaging become the must-have requirements, then a possible data plan or Wi-Fi connectivity will be further justified as a requirement. Also, instructors valued utilizing devices that possess touch screen capability, which means screen size may become an issue for all users. Therefore, mobile learning devices such as smart phones may not be as good an option as tablets or laptop computers.

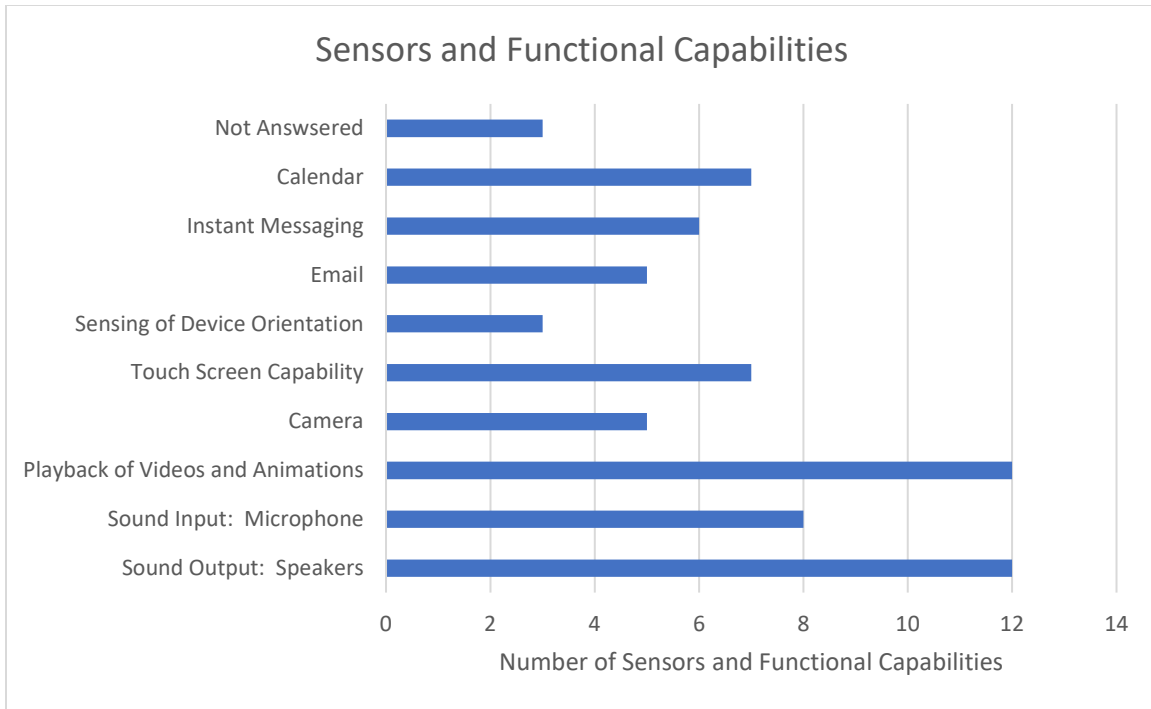


Figure 10. Expected Sensor and Functional Capabilities for a Mobile Device (Secondary Group-Question 1)

2. Limitations for Using Personal Devices

When participants were asked, what limitations might affect using personal mobile devices to support their organization's class activities, personal unwillingness to use own device was identified as the top answer (Figure 11). This was followed by limited device capability and limited data plan. In addition to the expected limitations, the participants also identified other perceived challenges (Table 8).

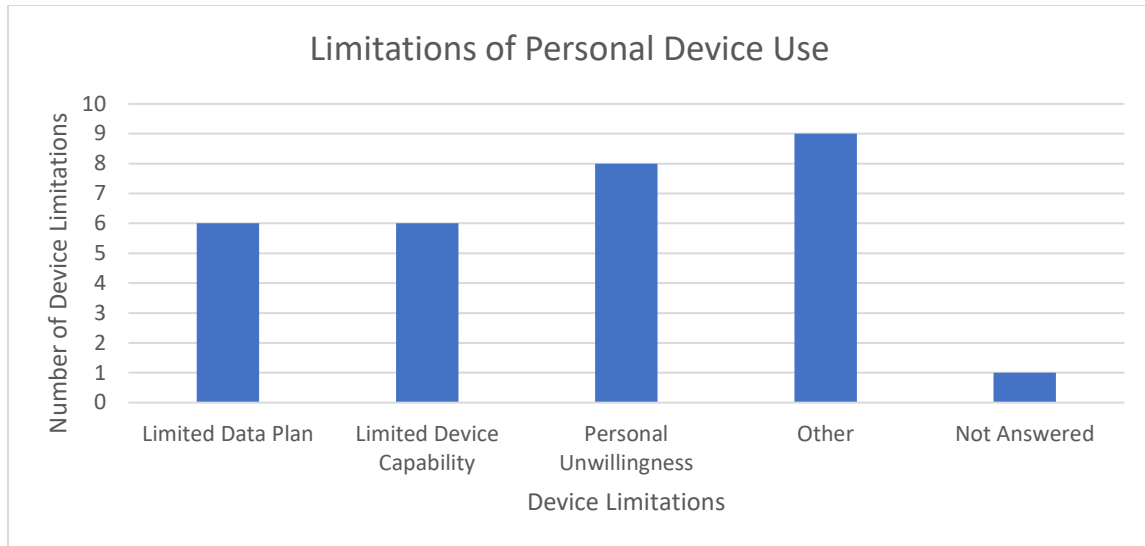


Figure 11. Identified Limitations for Using Personal Devices
(Secondary Group-Question 2)

Table 8. Other Identified Limitations for Using Personal Mobile Devices
(Secondary Group-Question 2)

Other Identified Limitations for Using Personal Devices
1. Connectivity 2. Current software 3. Compromising of testing materials 4. Lack of student discipline 5. Couse material is classified 6. Irresponsible students losing or breaking their mobile device

Personal unwillingness will be a challenge if personal mobile devices are integrated as part of the practice for mobile learning. Unwillingness to use personal devices will help to guide Navy leadership in deciding the need and expectation for the use of mobile technology. The downside to using personal devices relates to the findings elaborated by Khaddage (2015), where they reported a concern for student's personal devices running the necessary applications to deliver course content. This concern was shared by one participant's response for current software as a limitation (Table 8). A limited data plan

was one of the identified responses and may tie in with personal unwillingness. However, future studies will need to be conducted to assess the true nature of unwillingness within a military population. No identified literature studies could be found.

A further look into the use of personal mobile devices versus government-issued mobile devices for mobile learning can also be looked at from a pros (advantages) versus cons (disadvantages) approach. Table 9 identifies some of those properties that the decision-makers should consider. As the table illustrates, the cons of using personally owned devices outweigh the pros. The main pro for government issued is that devices would be guaranteed to meet the mobile learning hardware functional requirements and government would have full control over the choice and management of that device.

Table 9. Personally Owned vs. Government Issued Mobile Devices

	Pros	Cons
Personally owned	• No additional cost for government • User already familiar with device	• Use of personal device memory for work-related data • Use of mobile data plan for work-related activities • User may be hesitant to use personal device for work activities • User may be concerned about government tracking
Government owned	• Does not require use of personal device for work related activities • Guaranteed uniformity in terms of device type and operating system-lower cost of developments and updates • Government has a full control of all applications and content (reduced possibility of malware)	• Additional cost to government to initially procure and update devices as required • Possible poor user familiarity with new device (may require addition training or time to learn) • Requires inventory tracking and auditing support

	Pros	Cons
Personally owned or government owned	• Access to device and learning applications 24/7	1. Potential for loss/theft 2. Requires dealing with cybersecurity issues/updates

The identification of other limitations to using personal mobile devices (Table 8) added the insight on the challenges the Navy will need to consider when implementing mobile technology. The concern for connectivity links back to the section that elaborated the issues related to delivery of current technology (Chapter IV, Section B, Subsection 4). The employment of personal devices will need to be supported by reliable connectivity. The consideration of compromising testing materials (students sharing the test questions with those who have not taken the test), lack of student discipline, and student responsibility suggests an apprehension by instructors regarding the use of student's personal devices. The identification of course material classification is a concern within the military context since information is meant to maintain a military advantage over adversaries. Although the investigation of cybersecurity is outside of the realm of this research project, it is identified as a concern among instructors.

3. Expected Interactions with Course Content for Mobile Technologies

Types of interactions with mobile technology that were significantly valued by instructors were the abilities to send and receive attachments and take assessments (test and quiz). They also seemed to value the ability to collaborate within a team setting. All the above instructor-valued attributes require connectivity and are also considered functional requirements. Balacheff (2009) states that connectivity is one of the critical attributes required for successful mobile learning technology implementation. Institutions that utilize mobile technology with connectivity will require technical support by their institutional to ensure student access is uninterrupted.

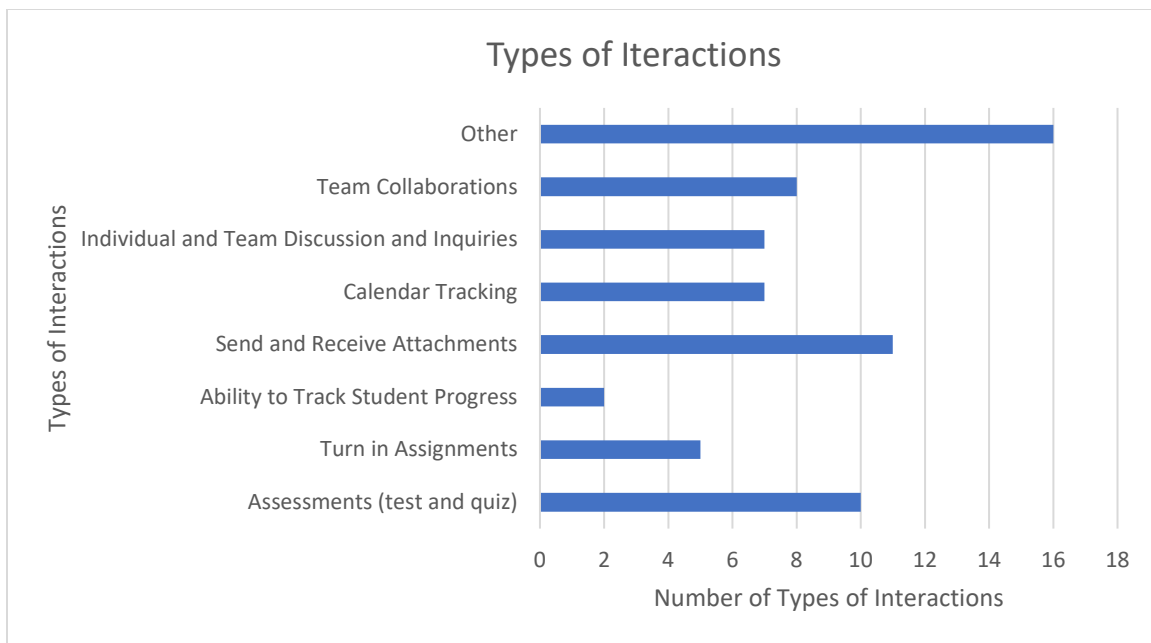


Figure 12. Expected Interactions Between Course Content and Mobile Technology (Secondary Group-Question 3)

However, not everyone will be on board with the implementation of mobile learning technology. As shown in Table 10, some believe that mobile learning technology is not required, and that making on-line testing being a requirement is unnecessary. However, if instructors start to witness students' ability to take online assessments and exams, and submit those tests anytime and from anywhere, then the instructors who are not on board may change their minds.

Table 10. Other Types of Interactions Identified by Participants

Other Statements Issued by Interview Participants
1. Mobile technology not needed.
2. None of this is needed. We are using on-line testing because it is required, not because it is needed. When it works it is helpful. When it doesn't work, the lack of in-place paper testing results in more loss of training time.
3. Note taking.
4. Annotation of course material.
5. Organized search and store digital course material.

4. Expectations for Using Mobile Technology to Complete Course Objectives

Regarding the perceived expectation for about the use of mobile technology to support course objectives (Table 11), there was a similarity with the ability of mobile devices to assist students in remembering, understanding, and applying course material (Figure 13). The ability to analyze data using information delivered in the course was also listed as a course objective expectation (Figure 13).

Table 11. Description of Course Objectives

Couse Objective	Description
Remember course material.	Student can retrieve stored terms and definitions without necessarily understanding them.
Understand course material.	Explain concepts in oral or written form.
Apply course material.	Solve problems or implement procedures of conventional types given appropriate data and computational resources.
Analyze data using information delivered in the course.	Given a system or process, explain relationships and interactions between each constituent part.
Evaluate data using information delivered in the course.	Use criteria for evaluation to support detailed analysis or critiques of the effectiveness of systems and processes in meeting a stated requirement.
Create a model based upon material introduced in the course.	Build functioning systems or produce a detailed design.

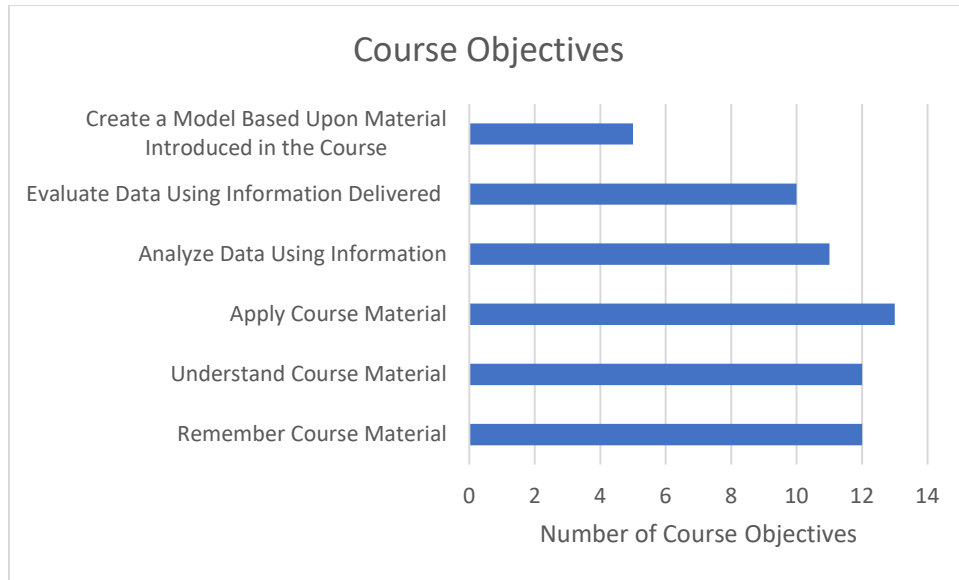


Figure 13. Expected Course Objectives for Students (Secondary Group-Question 4)

The Course Objectives chart (Figure 13) further emphasizes the desired functional requirements. Tablets and laptops have screens (visual displays) that are large enough screens to allow instructors and students conduct effective analysis and manipulation of the data sets. While smartphones may possess the same abilities, their smaller screen size is not optimized for those tasks. According to Nedungadi and Raman (2012), the size of smartphone keyboard also hinders learning, thus presenting difficulties for applying and analyzing course material. In addition to a smartphone's small screen size, they do not possess the same memory capacity as tablets and laptops.

D. INSTRUCTOR FAMILIARITY WITH TECHNOLOGY

The Tertiary Group of Questions (Table 5) was designed to get an idea of mobile device ownership and usage among the participant group. Based on the results shown in Figure 14, less than half of the participants owned tablets. The lack of ownership outlined a potential apprehension to adopting tablets. In fact, according to Figure 9, only a few instructors that were critical of mobile learning technology possessed a lack of tech skills which can be attributed to the lack of familiarity with tablets. The lack of tech skills correlated with Mac Callum's study (Mac Callum et al., 2014), which addressed the

importance of the end user's digital literacy. Most instructors we interviewed were apprehensive of implementing mobile learning technology because they believed that funding would not be sufficient. Thus, if the Navy can secure annual funding and make sure that training commands can support mobile technology and infrastructure, the apprehensive instructors are likely to support implementation.

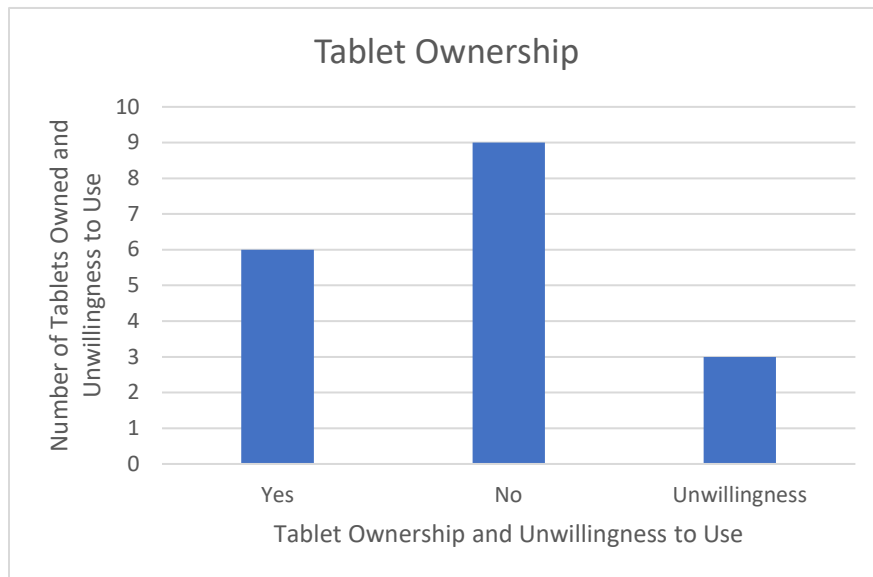


Figure 14. Tablet Ownership and Unwillingness to Use (Tertiary Group-Question 1)

E. PATHWAY TO PROCUREMENT AND IMPLEMENTATION

The procurement process for training centers is a multi-step pathway that is illustrated in Figure 15. Once an organization had established its learning objectives, the next step is selection of the optimal device to meet the training needs. For training centers to identify the optimal mobile learning device, they need to identify the functional requirements that we discuss in sub-section 1 below. Next, training centers identify possible roadblocks to implementation and acceptance, which we discuss in sub-section 2. Another important aspect of procurement that training centers need to consider are the additional costs and cost savings, which are discussed in sub-section 3. Training centers then determine the best option for ownership, which is discussed in sub-section 4. Lastly,

training centers at this point are ready to select the optimal device or mix of devices for procurement, which is discussed in sub-section 5 and examine the options for connectivity for their training environment, which is discussed in sub-section 6.

PATHWAY TO PROCUREMENT AND IMPLEMENTATION

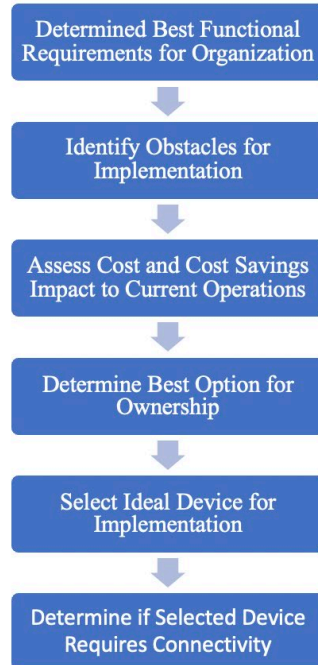


Figure 15. Pathway to Procurement and Implementation

1. Functional Requirements.

As training commands look to procure mobile devices, particular care should be invested to ensure the optimal device is chosen for the appropriate lesson plan. Table 12 describes the recommended functional requirements based on the responses of interviewed Navy instructors.

Table 12. Consideration When Choosing Functional Requirements

Functional Requirements	Considerations
Screen size	Size is congruent with software and lesson instruction. Consider nothing smaller than a tablet
Network connectivity	Ensure reliable network infrastructure
Sounds (speakers)	Compatible with software and lesson instruction
Video playback and animations	Compatible with software and lesson instruction
Touch screen capability	Compatible with software and lesson instruction
Capability to take tests/ quizzes	Access to LMS
Instant messaging/chat	Consider access through Gmail or other
Other Requirements	Considerations
Training	Ensure contract includes plan for training
Maintenance plan	Ensure contract includes plan for maintenance + ensure that (when possible) elements of the maintenance can be done by trainees (self-sustainable mode of operation)

2. Obstacles for Implementation

Table 13 presents the obstacles for implementation and possible mitigation steps based on requirements listed in Table 12. The list is not all inclusive- other obstacles will arise as plans for implementation are worked into the Navy education and training plan. Leaders and planners should always be cognizant of developing challenges and ensure that the steps are taken to promote successful implementation.

Table 13. Obstacles to Implementation

Obstacles	Mitigation Steps
Not all devices operate the same way	Provide government issued devices
Support for remote locations	Ensure training content can be downloaded for later use when there is no network connectivity
Lack of tech skills/anxiety	Vendor training for a specified period determined by the customer
Lack of instructor time to maintain devices	Ensure contract includes plan for maintenance
Fear of lack of funding	Ensure implementation of new technology is sustainable with current and future budget plans

3. Additional Costs and Cost Savings

Appendix C describes the potential costs for purchasing mobile learning equipment and services like training and maintenance. This is meant to be a guide for the planning for procuring equipment. For accurate estimates, market research should be conducted by the procuring authority.

Table 14 displays categories of additional costs to the status quo, and Table 15 identifies costs savings or benefits training centers should consider when procuring mobile learning hardware to satisfy their functional requirements. Training centers can consider cost-effective options when purchasing the hardware, whether it is bulk ordering or per unit. In addition, training centers should identify the advantages that mobile learning can provide the instructors for their particular type of training, such as potential instructor time saved for preparation that can be used to increase interaction with students for personalized, longer lasting learning activities. Maintenance of the mobile learning hardware, and training if required are also additional costs training centers will need to consider.

Table 14. Consideration of Additional Cost

Cost of Procurement of Technology: Additional Costs	
(1) Hardware + Software	
(2) Option Bulk Purchase	
	Small purchases < 50 devices
	50+ devices bulk
(3) Option Price per device	
	Tablet, laptop
	Smart phone
(4) Basic Software	
	Service contract
(5) Service Contract	
	WiFi
	Pucks for hot spots
(6) Training of Instructors	
	Contract line item (periodic fees)
(7) Storage for Equipment and Data	
	Equipment and IT manager
(8) Interoperability with existing infrastructure	
	MLS (Moodle)
	My Navy Learning
	NMCI
	CeTARs
(9) Time/Resource	
	Adapt course content and learning activities to mobile/hybrid delivery

Table 15. Consideration of Cost Savings or Benefits

Additional Cost Savings/Benefits
Reduced paper, copying, and time to prepare, grade, and store hard copy documents.
Efficiency in training by allowing instructors more time for personalized training.
Support of new teaching and learning approaches that were not possible before.
Increased engagement and efficacy for longer-lasting learning.
Increased portability of course content for use as refresher, as needed, post training.
Maintain the instructor-student and student-student interaction capability in a hybrid or fully distributed training environment.
Ability to deliver training in a hybrid or fully distributed way - Sailors no longer needed to go on TAD for training (for the duration of the entire course or a portion of the training).
Meet functionality requirements to deliver training in an effective and engaging way.

4. Device Ownership

Device ownership is an important aspect that needs to be examined when integrating mobile devices as part of an organization's training program. Should ownership and costs be the sole responsibility of the parent organization, or can training be accomplished using privately owned mobile devices? Is it possible to adopt a hybrid approach? Figure 16 provides details about advantages and disadvantages of each option.

There are two scenarios that are possible if an organization uses personally owned devices in training context. One involves a hybrid approach where a portion of the students use their personally owned devices while another group uses government issued devices; an alternative hybrid approach would be that students use smartphones and government provides a limited number of tablets that could be used to support some elements of students' curricula. The other approach assumes only the use of personally owned devices.

Based upon data collected in our interviews, the disadvantages of using personally owned devices overshadowed their advantages.

PERSONALLY OWNED VS GOVERNMENT OWNED MOBILE DEVICES

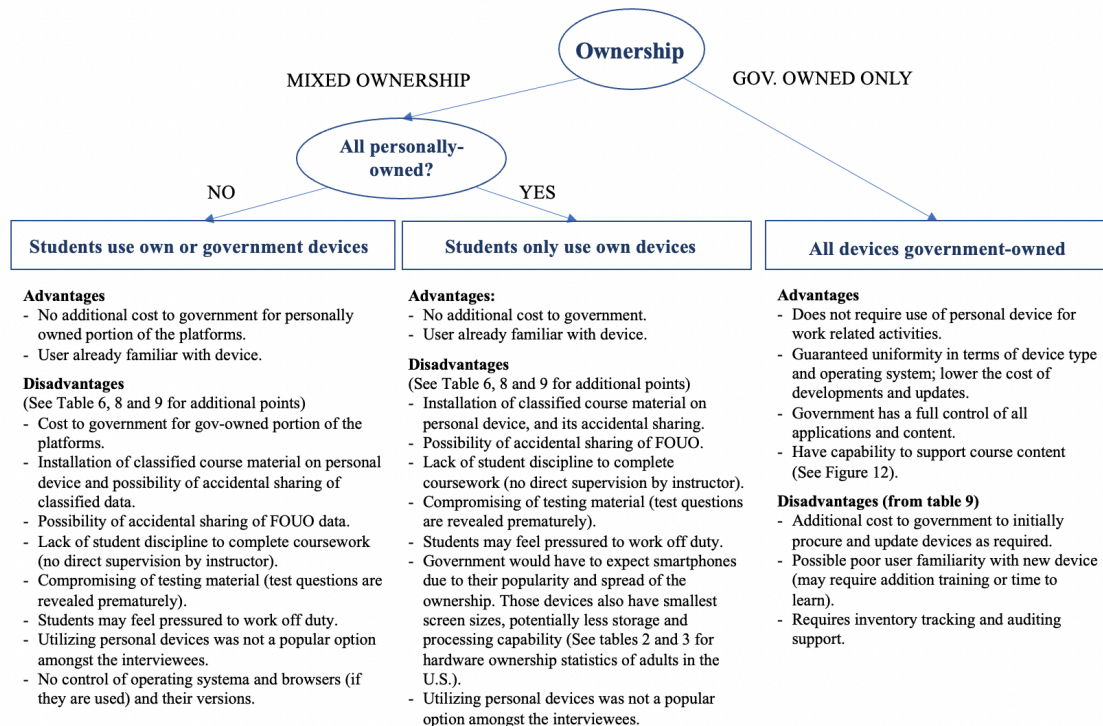


Figure 16. Advantages and Disadvantages of Device Ownership

5. Mobile Device Selection

The assortment of currently available mobile devices has advantages and disadvantages when it is considered for use in mobile learning. Figure 15 identifies some of the advantages and disadvantages for their use based upon data collected during participant interviews. Prior to procurement and implementation, naval leadership and planners should first consider each device's characteristics and then choose the option best suited to achieve their organization's training objective.

Nine out of the fifteen interview participants (60%) reported no tablet device ownership (Figure 14). The reported number was slightly higher than the data reported by

the Pew Research Center (2021) of 53% (Table 3). However, 85% of the adult U.S. population is identified to own a smartphone (Pew Research Center, 2021). If personally owned devices are considered for mobile learning, connection to the LMS or any training content would have to occur by a smartphone. For individuals who do not own any type of mobile device, government issued device would be required.

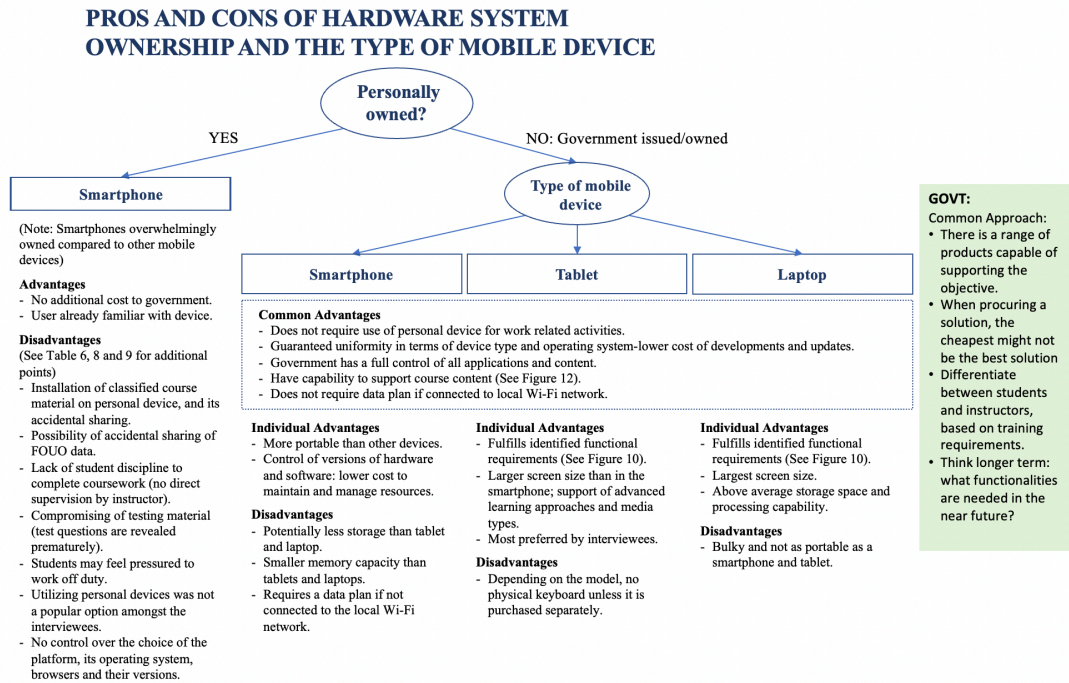


Figure 17. Mobile Device Hardware Advantages and Disadvantages

6. Network Connectivity

Adoption of mobile learning requires network connectivity either in the form of Wi-Fi or a service data plan. Network access by mobile devices prior to procurement should be considered to optimize usage, manage expectations, and improve mobile learning adoption. Figure 17 identifies the advantages and disadvantages for land-based connectivity. Figure 18 examines connectivity of a sea-based environment.

ACCESS TO LEARNING MANAGEMENT SYSTEM (LMS) WHILE LAND-BASED

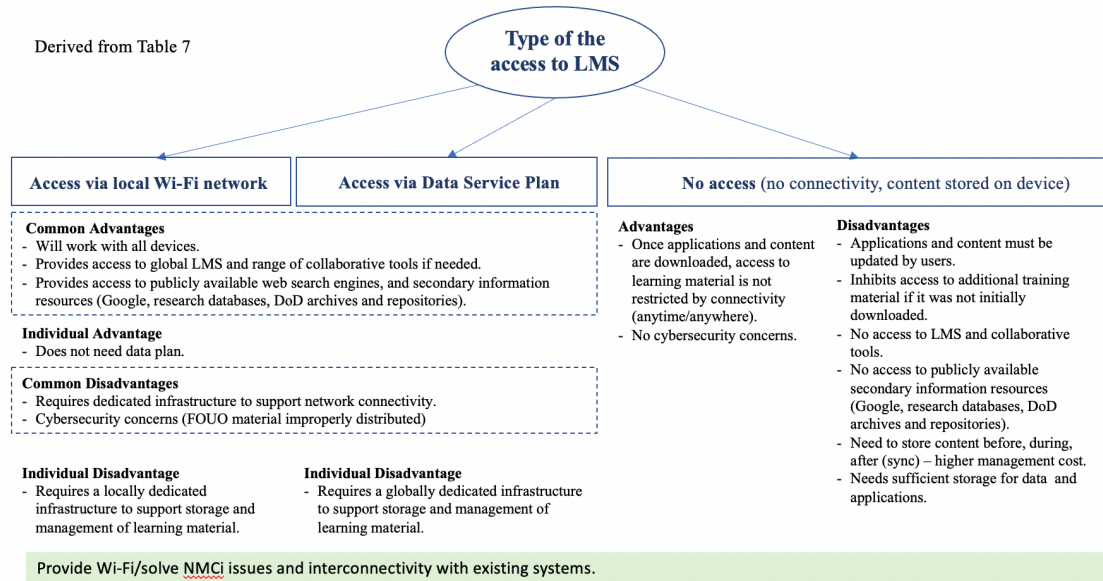


Figure 18. Advantages and Disadvantages of Land-based Connectivity

ACCESS TO LEARNING MANAGEMENT SYSTEM (LMS) WHILE SEA-BASED

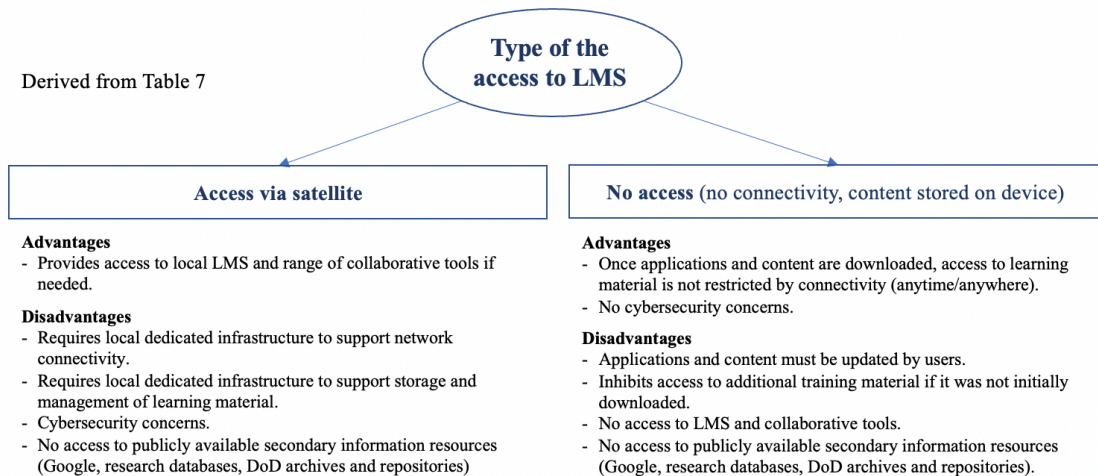


Figure 19. Advantages and Disadvantages of Sea-based Connectivity

When mobile training is land-based, training programs can access an LMS via Wi-Fi or a commercial data plan. If a Wi-Fi system is adopted as a primary form of delivery, the training organization will need to ensure current network infrastructure meets the needs of the organization. Interviews with participants identified a concern with current network connectivity (Table 6). Establishing a reliable network will mitigate concerns and improve mobile learning adoption. If a commercial data plan is used, an evaluation of service connectivity is needed with respect to the training area. Limited connectivity can arise due to inadequate cell tower availability or physical barriers that would inhibit cell service. Additionally, some locations may inhibit access by a commercial service plan due to engineered controls or limited cell tower availability in that area.

Mobile learning conducted at-sea will need to occur using Wi-Fi as the commercial service plans are unable to provide connectivity in remote ocean locations. Like a land-based scenario, a reliable network infrastructure will be essential to deliver readily available training. Prior to implementing mobile learning, Navy leadership and planners will need to assess current infrastructure to make sure it is sufficient to meet the organization's training objectives.

Mobile learning can occur when no connectivity exists. Under these conditions, content material will need to be downloaded prior to loss of connectivity to the network and LMS. As with other approaches, there are advantages and disadvantages to this system. However, mobile devices can still play an important part by providing access to information anytime, anywhere. Regardless, a setup of such a system will need to include participants' awareness of the system limitations to manage expectations. An example of such situation would be having access to an outdated training guideline that has been superseded by new instruction due to not having the connection with the host (most updated) LMS.

V. CONCLUSIONS

In this study, the aim was to take a systematic approach to develop a decision-support model for identifying mobile learning technologies that will allow Navy training commands to deliver RRL to meet the CNO's vision and to provide a procurement roadmap to identify the best-value solution. The hardware and software options for mobile training are evaluated based on the customer's (training center's) functional requirements and costs.

We addressed two main research questions:

- What mobile learning options satisfy the requirements of naval training centers (instructors)?
- What is the best value option for procurement of mobile learning technologies, based on the pros and cons of each device relative to type of the training?

The approach we used to address these questions included interviews with instructors at two training centers as well as a systematic review of published studies to develop of guide to procuring mobile learning technology (smartphones, tablets, and laptops). Our research suggests that tablets and laptops might be the preferred options given the significant potential end-users' pushback to use personal mobile devices to support learning. Therefore, we find that the optimal solution to the choice of personal-versus-government mobile technology use appears to be the use of government owned devices.

The data we collected in our interviews from the two training centers suggest that tablets and laptops are favored over smartphones as optimal devices for mobile learning. The contributing functional requirement for their preference was primarily the screen size. However, if the Navy was to procure the preferred mobile learning hardware, tablets are favored compared to laptops and smartphones in terms of their physical attributes and price. For example, if the government was to purchase tablets in the United States, their prices start from \$329.99 (Bestbuy, n.d.-c). Also, tablets are more convenient for the users to carry while travelling compared to bulkier hardware such as a laptop. The price of the smartphones also renders them as not being the ideal option - their cost starts approximately

at \$580.27 (O'Dea, 2020). Therefore, based on functional requirements reviewed in our study, this study recommends tablets for mobile learning in the Navy.

A. RECOMMENDATIONS FOR FURTHER STUDIES

1. Expanding Applicability to Other Navy Training Commands

Our study suggests that future research regarding mobile learning technology to deliver RRL to sailors, should focus on additional approaches that were not used in our study. We recommend conducting a set of focus groups throughout the Navy's education and training commands; those focus groups should involve students (trainees), instructors and program managers. Focus groups that involve a much large population are recommended because their results will provide more data and better statistical analysis compared to the data received from the 16 instructors. Receiving data from other domains may also prove that Navy may need to consider additional functional requirements to make sure the optimal solution gets selected to support mobile learning.

2. Assessment of Network Infrastructure

Another recommended study would be to evaluate current Navy-owned infrastructure that can be used to implement mobile learning technology. One of the functional requirements from instructor interviews stressed the importance of connectivity. However, the research conducted in this thesis did not specifically address the infrastructure that would be required by the Navy to execute a successful mobile learning technology implementation.

The finding from our study suggests a future role for mobile technology within a military environment. We hope that the results of our research effort could be used as a starting point and a basis for discussion with a larger number of stakeholders. Those combined findings will ensure that the implementation of RRL is done in an optimal way and given the best chance for its complete success.

APPENDIX A

Interview Note: The target audience for our questions is instructors (A) and training managers (B). Designation Q#A/B signifies that question is meant for instructors and training managers. Designation Q#A signifies questions meant for instructors alone. Designation Q#B signifies questions meant for training managers exclusively.

PRIMARY GROUP OF QUESTIONS

Q1A/B: What type of courses do you teach/ manage?

- Additional prompts, if needed
- Q: Entry-level, more advanced? With large hands-on training component?

Q2A/B: How does your organization use technology part of the training delivery, if at all??

- Additional prompts, if needed, to define the status quo.
- In the training classroom or shop: projector, computers (govt issued, personal?)
- Use a learning management system (LMS)?
- In the instructor's office, computer connected (to the Internet)?
- Other?

Q3A/B: What mobile learning device(s) could support your organization's teaching approaches? Choose the option(s) that are applicable to your organization.

- Mobile / smartphone
- Tablet
- Others, please specify

Q4A/B: What resources does your organization use to deliver current training?

- X Manpower hours per week of course (or per year)
- \$ for IT maintenance and updates for LMS & network, per year
- \$ for training instructors to use technology, per year
- \$ for devices, etc (per year).

Q5A/B: What are some of the main issues currently identified in terms of capabilities/ functionalities to deliver the training?

NOTE: (to better align with the RRL) (I.e., not enough instructor hours, lack of tech skills, resistance to change, costly change because of lack of hours, lack \$ or manpower to do maintenance, time required to get on network behind firewalls, connectivity, not enough time to accomplish learning objectives in class time, or no ability to personalize training.

SECONDARY GROUP OF QUESTIONS

Q1A/B: What type of sensors and functional capabilities of a mobile device would be needed to deliver the course material? Choose the option(s) that are applicable to your organization.

- Sound (audio) output: speakers
- Sound (audio) input: microphone
- Playback of the videos and animations
- Camera (optical sensor)
- Touch screen capability
- Sensing of device orientation (gyroscope)
- Email

- Instant messaging
- Calendar

Q2A/B: What limitations might affect using personal mobile devices to support class activities? Choose the following option(s) that are applicable to your organization.

- Limited data plan
- Limited device capability
- Personal unwillingness
- Other

Q3A/B: What types of interactions with the course content would need to be facilitated by mobile technology options? Choose all the option(s) that are applicable to your organization.

- Assessments (test & quiz)
- Turn in assignments
- Ability to track student progress/grades
- Send and receive attachments/assignments
- Calendar tracking /reminder capability
- Individual and team discussion and inquiries
- Team collaboration
- Anything else: _____

Q4A/B: What are the course objectives that students are expected to learn? Choose the option(s) that are applicable to your organization.

- Remember course material (student can retrieve stored terms and definitions without necessarily understanding them)
- Understand course material (Explain concepts in oral or written form)
- Apply course material (Solve problems or implement procedures of conventional types given appropriate data and computational resources)
- Analyze data using information delivered in the course (Given a system or process, explain relationships and interactions between each constituent part)
- Evaluate data using information delivered in the course (Use criteria for evaluation to support detailed analysis or critiques of the effectiveness of systems and processes in meeting a stated requirement)
- Create a model based upon material introduced in the course (build functioning systems, or produce a detailed design)

TERTIARY GROUP OF QUESTIONS

Q1A/B: Do you own a smartphone?

- YES / NO
- If, YES, would you be willing to use it to access/manage training material?

Q2A/B: Which type of smartphone do you own (for your personal use)?

- iPhone (iOS based)
- Microsoft (Windows based)
- Samsung (Android based)
- Other

Q3A/B: Do you own a tablet device?

- YES / NO

- If, YES, would you be willing to use it to access/manage training material?

Q4A/B: Which type of tablet device do you own?

- iPad (iOS based)
- Microsoft (Windows based)
- Samsung (Android based)
- Amazon Fire HD
- Other

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APPENDIX B

Mobile Technology Questionnaire



* Required

Contact Information

1. *Please enter your name.* *

2. *Please indicate your role.* *

- ☐ Instructor
- ☐ Training Manager

Assessing Current Practices

3. *What type of courses do you teach/ manage?* *

- ☐ Aviation
- ☐ Construction
- ☐ Medical
- ☐ Engineering
- ☐ Other

4. *If you answered "Other" to the previous question above, please explain.*

Assessing Current Practices

5. ***Does your organization use technology to delivering training? ****

- ☐ Yes
- ☐ No

6. ***If you answered "Yes" to the previous question, What type of technology?***

Assessing Current Practices

7. ***What mobile learning device(s) could support your organization's teaching approaches? Choose the option(s) that are applicable to your organization. ****

- ☐ Mobile phone / smart phone
- ☐ Tablet
- ☐ Other

8. ***If you chose "Other" in the question above, please explain and why?***

Assessing Current Practices

9. Rank by order of importance the following resources your organization uses to deliver current training? *

Manpower hours/week (Instructor lead course training)

\$ for IT maintenance and updates for LMS & network, per year

\$ for devices, etc (per year)

\$ for training instructors to use technology, per year

10. If there are other resources your organization uses to deliver training that is not listed above, please indicate below.

--

Assessing Current Practices

11. ***What are some of the main issues currently identified in terms of capabilities/ functionalities that can prevent delivery of training? ****

- ☐ Not enough instructor hours to maintain or utilize devices
- ☐ Lack of tech skills (instructors/training managers)
- ☐ Resistance to change within organization
- ☐ Lack \$ or manpower to do maintenance
- ☐ No organizational connectivity (Wi-Fi) to support
- ☐ Not enough time to accomplish learning objectives in class time
- ☐ No ability to personalize training
- ☐ Other

12. *If you chose "Other" in the question above, please explain.*

Defining Mobile Technology Characteristics and Expectations

13. ***What type of sensors and functional capabilities of a mobile device would be needed to deliver the course material? Choose the option(s) that are applicable to your organization. ****

- ☐ Sound (audio) output: speakers
- ☐ Sound (audio) input: microphone
- ☐ Playback of the videos and animations
- ☐ Camera (optical sensor)
- ☐ Touch screen capability
- ☐ Sensing of device orientation (gyroscope)
- ☐ Email
- ☐ Instant messaging
- ☐ Calendar

Defining Mobile Technology Characteristics and Expectations

14. ***What limitations might affect using personal mobile devices to support class activities? Choose the following option(s) that are applicable to your organization. ****

- ☐ Limited data plan
- ☐ Limited device capability
- ☐ Personal unwillingness
- ☐ Other

15. *If you chose "Other" in the question above, please explain.*

Defining Mobile Technology Characteristics and Expectations

16. ***What types of interactions with the course content would need to be facilitated by mobile technology options? Choose all the option(s) that are applicable to your organization. ****

- ☐ Assessments (test & quiz)
- ☐ Turn in assignments
- ☐ Send and receive attachments/assignments
- ☐ Calendar tracking /reminder capability
- ☐ Individual and team discussion and inquiries
- ☐ Team collaboration
- ☐ Other

17. *If you chose "Other" in the question above, please explain.*

Defining Mobile Technology Characteristics and Expectations

18. ***What are the course objectives that students are expected to learn? Choose the option(s) that are applicable to your organization. ****

- ☐ **Remember course material** (student can retrieve stored terms and definitions without necessarily understanding them)
- ☐ **Understand course material** (Explain concepts in oral or written form)
- ☐ **Apply course material** (Solve problems or implement procedures of conventional types given appropriate data and computational resources)
- ☐ **Analyze data using information delivered in the course** (Given a system or process, explain relationships and interactions between each constituent part)
- ☐ **Evaluate data using information delivered in the course** (Use criteria for evaluation to support detailed analysis or critiques of the effectiveness of systems and processes in meeting a stated requirement)
- ☐ **Create a model based upon material introduced in the course** (build functioning systems, or produce a detailed design)

Instructor Familiarity with Technology

19. ***Do you own a smartphone? ****

- ☐ Yes
- ☐ No

20. ***If you own a smartphone, would you be willing to use it to access/manage training material?***

- ☐ Yes
- ☐ No

Instructor Familiarity with Technology

21. ***Which type of smartphone do you own (for your personal use)? ****

- ☐ Phone (iOS based)
- ☐ Microsoft (Windows based)
- ☐ Samsung (Android based)
- ☐ Other

22. ***If you chose "Other" in the question above, please explain.***

Instructor Familiarity with Technology

23. ***Do you own a tablet device? ****

- ☐ Yes
- ☐ No

24. ***If you own a tablet device, would you be willing to use it to access/manage training material?***

- ☐ Yes
- ☐ No

Instructor Familiarity with Technology

25. ***Which type of tablet device do you own?***

- ☐ iPad (iOS based)
- ☐ Microsoft (Windows based)
- ☐ Samsung (Android based)
- ☐ Amazon Fire HD
- ☐ Other

26. ***If you chose "Other" in the question above, please explain.***

APPENDIX C

Status Quo: Traditional Class (Tangible)				
	Purchases	Quantity	Unit Cost	Total cost
1	Paper	1	\$ 110.00	\$ 110.00
2	Stationary	1	\$ 28.56	\$ 28.56
3				\$ -
4				\$ -
5				\$ -
Total				\$ 138.56

Instructor Time Spent on Class Preparation (Intangible)				
Total Time Instruction per Number of Students				
1	Instructor hours	1	2	2
on Preparation per Number of Classes				
2		2	1	2
Total				4 hours

Device Type	Device Description	Model	Price	Source Price
Tablet	iPad 10.2" with Wi-Fi 64GB	MK2K3LL/A	\$ 329.99	(Bestbuy, n.d.-c)
Tablet	iPad 10.2" with Wi-Fi + Cellular 256GB	MK6A3LL/A	\$ 609.99	(Bestbuy, n.d.-c)
Tablet	Samsung Galaxy Tab A7 10.4" with Wi-Fi 64GB	SM-T500NZAEXAR	\$ 279.99	(Bestbuy, n.d.-e)
Tablet	Samsung Galaxy Tab S7 12.4" with Wi-Fi 256GB	SM-T970NZKEXAR	\$ 929.99	(Bestbuy, n.d.-e)
Tablet	Microsoft Surface Go3 10.5" with Wi-Fi 64GB	8V6-00001	\$ 399.99	(Bestbuy, n.d.-f)
Tablet	Microsoft Surface Pro 7 12.3" with Wi-Fi 256GB	VNX-00016	\$ 1,499.99	(Bestbuy, n.d.-f)
Tablet	Panasonic 12" Toughbook 33 Tablet with Wi-Fi 256GB	CF-33LE-01VM	\$ 3,439.50	(B&H Photo Video, n.d.-a)
Laptop	Panasonic 14" Toughbook 55 Laptop with Wi-Fi	FZ-55C8601VM	\$ 2,653.00	(B&H Photo Video, n.d.-b)
Laptop	Macbook Air 13.3" Laptop with Wi-Fi 256GB	MGN63LL/A	\$ 999.99	(Bestbuy, n.d.-d)
Laptop	Macbook Pro 14" Laptop with Wi-Fi 512GB	MKGP3LL/A	\$ 1,999.00	(Bestbuy, n.d.-d)
Laptop	HP 14" Laptop with Wi-Fi 64GB	14-dq0001dx	\$ 249.99	(Bestbuy, n.d.-b)
Laptop	HP ENVY 17.3" with Wi-Fi 512GB	17-m-ch1013dx	\$ 1,279.99	(Bestbuy, n.d.-b)
Laptop	Dell Inspiron 7000 13.3" with Wi-Fi 512GB	i7306-5934SLV-PUS	\$ 949.99	(Bestbuy, n.d.-a)
Laptop	Dell Inspiron 7000 17" with Wi-Fi 512GB	i7706-7814SLV-PUS	\$ 1,379.99	(Bestbuy, n.d.-a)

COA: Blended (Traditional + Digital/mobile tech)					
Hardware	Purchases	Quantity	Unit Cost	Total cost	Assumptions
Tablets	iPad (11" display)	30	\$ 700.00	\$ 21,000.00	iPad price is based off iPad air price listed on website
	Training	12	\$ 1,000.00	\$ 12,000.00	Purchase of Training Contract was Annual and price was utilized as a placeholder
	Maintenance	12	\$ 1,000.00	\$ 12,000.00	Purchase of Maintenance Contract was Annual and price was utilized as a placeholder
	Total			\$ 45,000.00	
Assumptions					
	Samsung S7	30	\$ 1,000.00	\$ 30,000.00	Samsung S7 based off internet search
	Training	12	\$ 1,000.00	\$ 12,000.00	Purchase of Training Contract was Annual and price was utilized as a placeholder
	Maintenance	12	\$ 1,000.00	\$ 12,000.00	Purchase of Maintenance Contract was Annual and price was utilized as a placeholder
	Total			\$ 54,000.00	
Assumptions					
	Surface PXT-0001	30	\$ 1,008.31	\$ 30,249.30	Surface PXT-0001 based off GSA website
	Training	12	\$ 1,000.00	\$ 12,000.00	Purchase of Training Contract was Annual and price was utilized as a placeholder
	Maintenance	12	\$ 1,000.00	\$ 12,000.00	Purchase of Maintenance Contract was Annual and price was utilized as a placeholder
	Total			\$ 54,249.30	
Hardware	Purchases	Quantity	Unit Cost	Total cost	Assumptions
Laptops	Tough Book	30	\$ 2,653.00	\$ 79,590.00	Price based off google search
	Training	12	\$ 100.00	\$ 1,200.00	Purchase of Training Contract was Annual and price was utilized as a placeholder
	Maintenance	12	\$ 100.00	\$ 1,200.00	Purchase of Maintenance Contract was Annual and price was utilized as a placeholder
	Total			\$ 81,990.00	
Assumptions					
	Mac Book	30	\$ 999.99	\$ 35,370.00	Price based off google search
	Training	12	\$ 100.00	\$ 1,200.00	Purchase of Training Contract was Annual and price was utilized as a placeholder
	Maintenance	12	\$ 100.00	\$ 1,200.00	Purchase of Maintenance Contract was Annual and price was utilized as a placeholder
	Total			\$ 37,770.00	
Assumptions					
	HP	30	\$ 1,279.99	\$ 24,000.00	Price based off google search
	Training	12	\$ 100.00	\$ 1,200.00	Purchase of Training Contract was Annual and price was utilized as a placeholder
	Maintenance	12	\$ 100.00	\$ 1,200.00	Purchase of Maintenance Contract was Annual and price was utilized as a placeholder
	Total			\$ 26,400.00	
Assumptions					
	Dell	30	\$ 1,379.99	\$ 27,000.00	Price based off google search
	Training	12	\$ 100.00	\$ 1,200.00	Purchase of Training Contract was Annual and price was utilized as a placeholder
	Maintenance	12	\$ 100.00	\$ 1,200.00	Purchase of Maintenance Contract was Annual and price was utilized as a placeholder
	Total			\$ 29,400.00	

WiFi	Company	Monthly Cost	Number of months	Total Cost	Assumptions
	Local Cable Company	\$ 100.00	12	\$ 1,200.00	Price of WiFi of \$100 was used as a placeholder
	AT&T	\$ 100.00	12	\$ 1,200.00	Price of WiFi of \$100 was used as a placeholder
	Starlink	\$ 100.00	12	\$ 1,200.00	Price of WiFi of \$100 was used as a placeholder

Tablet Total Cost with Wi-Fi			
Hardware	Cost with Local Cable Company	Cost with AT&T	Cost with Starlink
iPad	\$ 46,200.00	\$ 46,200.00	\$ 46,200.00
Samsung S7	\$ 55,200.00	\$ 55,200.00	\$ 55,449.30
Surface PXT-0001	\$ 55,449.30	\$ 55,449.30	\$ 55,449.30
Tablet Total Cost without Wi-Fi			
iPad	\$ 45,000.00		
Samsung S7	\$ 54,000.00		
Surface PXT-0001	\$ 54,000.00		
Laptop Total Cost with Wi-Fi			
Hardware	Cost with Local Cable Company	Cost with AT&T	Cost with Starlink
Toughbook	\$ 83,190.00	\$ 83,190.00	\$ 83,190.00
MacBook	\$ 38,970.00	\$ 38,970.00	\$ 38,970.00
HP	\$ 27,600.00	\$ 27,600.00	\$ 27,600.00
Dell	\$ 30,600.00	\$ 30,600.00	\$ 30,600.00
Laptop Total Cost without Wi-Fi			
Toughbook	\$ 81,990.00		
MacBook	\$ 37,770.00		
HP	\$ 26,400.00		
Dell	\$ 29,400.00		

Smart Phones					
Verizon	Hardware	Monthly Data Plan	Number of months	Total cost	Assumptions
	Base Year	\$ 1,000.00	12	\$ 12,000.00	Smart Phone and Data plan price was used as a placeholder
	Option Year 1	\$ 1,000.00	12	\$ 12,000.00	Smart Phone and Data plan price was used as a placeholder
	Option Year 2	\$ 1,000.00	12	\$ 12,000.00	Smart Phone and Data plan price was used as a placeholder
	Option Year 3	\$ 1,000.00	12	\$ 12,000.00	Smart Phone and Data plan price was used as a placeholder
	Option Year 4	\$ 1,000.00	12	\$ 12,000.00	Smart Phone and Data plan price was used as a placeholder
	Option Year 5	\$ 1,000.00	12	\$ 12,000.00	Smart Phone and Data plan price was used as a placeholder
	Total Cost of Service			\$ 72,000.00	
AT&T	Hardware	Monthly Data Plan	Number of months	Total cost	Assumptions
	Base Year	\$ 1,000.00	12	\$ 12,000.00	Smart Phone and Data plan price was used as a placeholder
	Option Year 1	\$ 1,000.00	12	\$ 12,000.00	Smart Phone and Data plan price was used as a placeholder
	Option Year 2	\$ 1,000.00	12	\$ 12,000.00	Smart Phone and Data plan price was used as a placeholder
	Option Year 3	\$ 1,000.00	12	\$ 12,000.00	Smart Phone and Data plan price was used as a placeholder
	Option Year 4	\$ 1,000.00	12	\$ 12,000.00	Smart Phone and Data plan price was used as a placeholder
	Option Year 5	\$ 1,000.00	12	\$ 12,000.00	Smart Phone and Data plan price was used as a placeholder
	Total Cost of Service			\$ 72,000.00	
T-Mobile	Hardware	Monthly Data Plan	Number of months	Total cost	Assumptions
	Base Year	\$ 1,000.00	12	\$ 12,000.00	Smart Phone and Data plan price was used as a placeholder
	Option Year 1	\$ 1,000.00	12	\$ 12,000.00	Smart Phone and Data plan price was used as a placeholder
	Option Year 2	\$ 1,000.00	12	\$ 12,000.00	Smart Phone and Data plan price was used as a placeholder
	Option Year 3	\$ 1,000.00	12	\$ 12,000.00	Smart Phone and Data plan price was used as a placeholder
	Option Year 4	\$ 1,000.00	12	\$ 12,000.00	Smart Phone and Data plan price was used as a placeholder
	Option Year 5	\$ 1,000.00	12	\$ 12,000.00	Smart Phone and Data plan price was used as a placeholder
	Total Cost of Service			\$ 72,000.00	

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