Leveraging Science and Technology to Launch Innovation in Learning

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ABSTRACT

In remarks about the *National Defense Strategy*, the U.S. Secretary of Defense, Jim Mattis, observed that in a time of rapid technological change and an over-stretched military, "Success does not go to the country that develops a new technology first, but rather, *to the one that better integrates it and more swiftly adapts its way of fighting*" (2018, emphasis is ours). Services within the Department of Defense (DoD) and agencies across the national security community are transitioning from an antiquated learning model to a more agile one that better leverages innovation and emerging learning science and technology (S&T). Service members and the civilian workforce seek to integrate these new learning capabilities and expect to obtain more personalized and accelerated learning as a result.

Previous research (Raybourn et al., 2017) identified key recommendations for enhancing learning within the national security domain. These recommendations focus on enhancing instructional quality, competencies, credentials, data analytics, data interoperability, personalization, learning on demand, integrated human–machine systems, creating a technology-enabled continuum of learning, providing multiple paths for achievement, and implementing an enterprise approach to talent management. Although there appears to be much support regarding *what* to implement, it is unclear *how* to achieve these outcomes, integrate with legacy programs, and swiftly adapt innovative prototypes to obtain effective real-world results.

This paper describes current progress, challenges, and opportunities in integrating innovative learning science, instructional methods, and technologies in military environments using specific examples from the Marine Corps Training and Education Command (TECOM) and partner efforts. In collaboration with S&T partners, TECOM conducted limited military user assessments of emerging adaptive mobile learning technologies. To date, the results appear promising and support the premise that newer Marines, for both the officer and enlisted ranks, prefer these new technology-enabled personalized learning delivery methods compared to "Industrial Age" instructional delivery methods. Finally, this paper discusses current limitations, challenges, future directions, and recommendations for integrating and more swiftly adapting emerging S&T into military training and education programs.

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INTRODUCTION

In remarks about the *2018 National Defense Strategy*, the U.S. Secretary of Defense, Jim Mattis, observed:

> "In this time of change, our military is still strong. Yet our competitive edge has eroded in every domain of warfare, air, land, sea, space and cyberspace, and it is continuing to erode. Rapid technological change, the negative impact on military readiness is resulting from the longest continuous stretch of combat in our nation's history and defense spending caps, because we have been operating also for nine of the last 10 years under continuing resolutions that have created an overstretched and under-resourced military." He went on to assert that, "Success does not go to the country that develops a new technology first, but rather, *to the one that better integrates it and more swiftly adapts* its way of fighting" (2018, emphasis is ours).

Both the *National Security Strategy* (Trump, 2017) and the *2018 National Defense Strategy* emphasize a need to encourage innovation to ensure the nation's technological edge. The unclassified summary of the *2018 National Defense Strategy* also states, "The current bureaucratic approach, centered on exacting thoroughness and minimizing risk above all else, is proving to be increasingly unresponsive. We must transition to a culture of performance where results and accountability matter" (Mattis, 2018).

In domains related to the "people sciences," the Department also risks the opportunity cost of not fully capitalizing on developments in science and technology (S&T) that could innovate its human capital management and improve personnel readiness. Individuals have come to expect more personalized, data-driven, responsive, artificial intelligence (AI) based, and technology-enabled solutions across their work and lives. These capabilities can be advantageously applied to personnel processes, such as training, education, career planning, accession, placement, and transition. However, the Department of Defense (DoD) and national security community, in general, have been slow to transition from an Industrial Age model of learning and development to a more agile talent management approach that better leverages innovation and emerging S&T.

Previous research (Raybourn et al., 2017) identified key recommendations to enhance learning and development within the national security community. These recommendations focused on enhancing instructional quality, competencies, credentials, data analytics, data interoperability, personalization, learning on demand, integrated human–machine systems, creating a technology-enabled continuum of learning, providing multiple paths for achievement, and implementing an enterprise approach to talent management. Although there appears to be consensus regarding *what* to do, a key challenge is *how* to implement these recommendations, integrate them with legacy military programs, and swiftly adapt innovative prototypes into effective real-world results—especially when governmental processes and policies create bottlenecks to change.

Implementing the recommendations described in Raybourn et al. (2017) will be difficult without commensurate changes in the overall learning and development model that DoD employs. That is, across the Department, a more integrated, learner-centric, personalized, data-driven, adaptive, and technology-enabled model is required. Many factors make this challenging, not the least of which is the military's risk aversion to making dramatic changes to its processes, policies, and technological infrastructure.

IMPLEMENTING INNOVATIVE LEARNING SCIENCE, METHODS, AND TECHNOLOGIES

Although the DoD has made some progress in implementing emerging learning science principles and contemporary educational technologies in military environments (e.g., see Barnieu et al., 2016; Vogel-Walcutt, Ross, & Phillips, 2016; Schatz et al., 2012), the Department has also missed many opportunities. The pervasive "research–practice gap," though not unique to the military, impedes swift progress. The more idiosyncratic barriers of the Defense Acquisition System and DoD culture also work against effective implementation of learning science, methods, and technologies.

The Research–Practice Gap

The research to practice gap affects every scientific field, defining the schism between theorists and researchers on one side, and policymakers and practitioners on the other. The gap is "characterized by a lack of reciprocal communication between the research and practice communities and limited implementation of evidence-based interventions in practice settings" (Neal et al., 2015, p. 422). In their review of the gap in the education domain, Hirschkorn and Geelan (2008) note several causes for it, including different cultures, values, goals, skills, and structural factors between the two communities. These challenges are prevalent in the military learning domain, as well. S&T performers lament that military training and education practitioners ignore their findings, and practitioners counter that the research is irrelevant to their operational challenges and real-world experiences. Practitioners observe that the studies are often conducted in controlled settings that fail to reflect the complexity and range of real-life conditions, while scientists complain about their lack of access to *in situ* military contexts.

Any successful implementation of learning S&T for the military needs to address both the generic and military-specific factors contributing to the research–practice gap. As the usability expert Donald Norman observed, "We need translational developers who can act as the intermediary, translating research findings into the language of practical development and business [or, in our case, *military*] while also translating the needs of business [military] into issues that researchers can address. Notice that the need for translation goes in both directions: from research to practice and from practice to research" (2010, p. 12).

DoD Acquisition System Barriers

The DoD's difficulty in quickly leveraging innovation is built into its acquisition system, including acquisition regulations, requirements processes, its hierarchical structures, and the slow nature of the funding (Program Objective Memorandum) processes. These are not new, nor newly observed, issues. For example, J. Ronald Fox, of the Harvard Business School, described a half-century worth of attempted repairs in his book, *Defense Acquisition Reform, 1960-2009: An Elusive Goal* (2011), and the House Armed Services Committee tried to examine the root causes of the system's flaws in their investigation, *Twenty-five Years of Acquisition Reform: Where Do We Go From Here?* (Schwartz, 2013).

Demands for acquisition reform have grown increasingly urgent. Since 2014, the National Defense Industry Association (NDIA) has petitioned Congress to improve the speed, cost-efficiency, effectiveness, and reliability of acquisition processes. NDIA documented twelve historical problem areas of the Defense Acquisition System in their 2014 open letter to the House and Senate Armed Services Committees (see Table 1). These documented problems include a lack of decision authority and accountability, a poor match between resources and requirements, and a dearth of data-driven acquisition decisions. Congress is attempting to meet the call – in the last three years, the number of acquisition reforms in the *National Defense Authorization Acts* (NDAAs) has nearly doubled, with the FY2016–FY2018 NDAAs each including roughly 82 acquisition reform provisions (see Schwartz & Peters, 2018 for a summary). Still, the system remains resistant to change.

Acquisition processes related to S&T suffer from additional and unique complications. Traditionally, DoD has viewed the S&T transition process as linear and unidirectional: the research community provides science and technology innovations, DoD laboratories mature these products into prototypes applicable to military operations, and then industry partners help integrate the new technologies into programs of record. However, this lengthy process runs counter to the best practices for invention and innovation, and it lacks room for agile development or adaptation.

1. Coordination between the requirements, budget, and acquisition processes is inadequate
2. Overly complex acquisition laws, regulations, and bureaucracy create unclear lines of authority and accountability
3. The acquisition workforce is not sufficiently staffed, trained, or experienced
4. The current acquisition system discourages an open and honest working relationship between government and industry
5. The acquisition workforce is not empowered to make use of all available options when making acquisition decisions
6. Congressional approval of defense budgets on year-to-year basis hinders long-term planning and execution of programs
7. Acquisition processes have not adapted to new technologies and a changing national security environment
8. Performance-based acquisition initiatives have not succeeded in shifting the focus from acquisition inputs to acquisition outcomes
9. Contractors are reluctant to make long-term investments in defense contracts
10. The oversight of acquisition inhibits improvements to the acquisition system
11. The acquisition system is unable to consistently and successfully predict the cost, schedule, and performance of defense systems
12. Lifecycle management of programs is inefficient and creates higher-than-necessary costs

Table 1. Twelve overarching problem areas in the Defense Acquisition System, identified by NDIA via a comprehensive literature review of studies dating back to 1949 (Etherton, Punaro, & Farrell, 2014, p. 5).

DoD acquisition processes also discourage participation from non-traditional S&T partners. The exploratory processes and lean management structures that often characterize innovative companies are antithetical to most DoD systems. DoD processes incentive "traditional" partners to provide incremental improvements to status-quo programs rather than disruptive revolutionary solutions. These traditional partners—who have learned to navigate DoD's byzantine processes—also have a vested interest in preserving the current system because it that gives them an edge over disruptive start-ups who lack documented past performance, the personnel and systems needed to navigate federal regulations, or the patience for counterintuitive DoD procedures.

Again, these observation are not new. As the Under Secretary of Defense for Research and Engineering (USD(R&E)), Mike Griffin, recently observed in his testimony to the House Armed Services Committee on Promoting DoD's Culture of Innovation (2018, April):

> In this increasingly competitive environment, the Department must pay much more attention to future readiness and regaining our Joint Force conventional overmatch. We must be willing and able to tap into commercial research, recognize its military potential, and leverage it to develop new capabilities, while also accounting for the operational and organizational constructs to employ them faster than our competitors. …One of my key priorities is to enable the Department to drive the military innovation cycle faster than any adversary to sustain technological superiority. Our competitors are closing the gap because of our processes, not our talent. We are striving to both develop innovative capabilities AND be innovative in our processes.

To ensure that warfighters have state-of-the-art capabilities, DoD needs S&T pathways that are more flexible and malleable to evolving needs, processes that encourage innovation and speed of delivery to users, and constructs that promote more collaboration between traditional and non-traditional partners. Advisors to senior DoD leadership, such as the Defense Innovation Board, have also recommended that DoD integrate best practices from the private sector for growing the workforce's intrapreneurship and internal explorations, while accelerating S&T integration into Service programs. Overall, it will likely require a solution set that combines a multitude of creative ideas and actionable solutions to finally reform DoD's acquisition institutions.

DoD Culture Barriers

Even if Congress could instantly reform DoD's acquisition system, the culture surrounding it would threaten to regress back to the status quo. As the NDIA's report on acquisition reform observed, "'Culture eats strategy for lunch,' as they say, and without some effort to combat entropy, the Defense Acquisition System will tend to produce in the future what it tends to produce in the present and has tended to produce in the past: outcomes at increasingly unaffordable cost" (NDIA, 2014, p. 6).

Acquisition professionals frequently demonstrate an aversion to risk that paralyzes their willingness to explore alternative methods, work outside of narrowly defined limits, or seek creative solutions to acquisition processes. In their 2016 biennial survey on acquisition policy, the Professional Services Council and Grant Thornton Public Sector cited agency workforce skills (29%), fear of oversight or protests (26%), and the Federal Acquisition Regulation (FAR) (17%) as the top three barriers to innovation. The reports went on to explain (2016, p. 15):

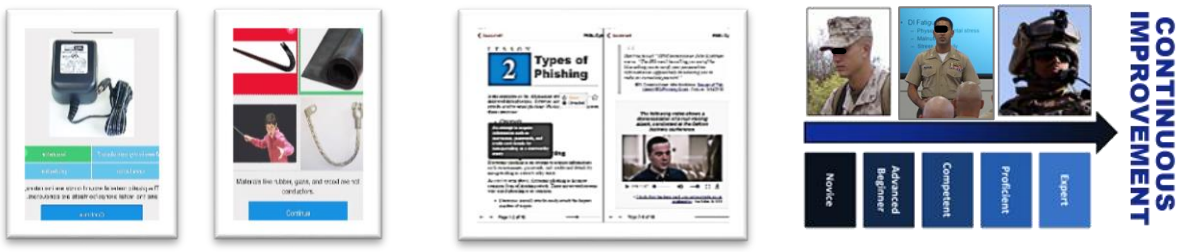
> These inhibitors are interconnected. Acquisition workers' inexperience means they tend to focus on compliance and don't understand the flexibilities in the FAR. As a result, they tend to be overly risk-averse out of fear of protests or punishment, rather than trying new and different things.

The report also criticizes the government's use of "destructive oversight" processes that "seem aimed at identifying fault and attributing blame after the fact" for "promoting a risk-averse culture and thus hampering successful outcomes and innovation" (p. 19). Even if this could be corrected, however, the DoD culture has other idiosyncrasies that specifically limit innovation in learning S&T. For instance, DoD demonstrates biases for seeking materiel versus non-materiel solutions, for integrating technologies rather than best practices, and for investing in systems versus personnel development. Training, education, and other personnel-related solutions are, anecdotally, viewed as "nice to have" rather than vital capabilities, and are typically less resourced compared to other "platform-centric" capability areas. Therefore, encouraging innovation in learning will require concerted and ongoing efforts to change the DoD culture, acquisition practitioners' aversion to risk, as well as the general perception of the inferiority of human-centric and non-materiel solutions.

MARINE CORPS LEARNING INITIATIVES

For the last decade, TECOM and collaborating partner organizations have pursued evidence-based learning science initiatives to enhance small unit training and instructor development, such as the Combat Hunter program of instruction, Small Unit Decision Making initiative, Making Good Instructors Great project (see Schatz et al., 2012), and the Master Instructor Development (MInD) initiative (see Vogel-Walcutt et al., 2016). Last year, TECOM also established the Future Learning Group, a special staff unit advising the Commanding General of TECOM, tasked with seeking and assessing innovative methods and technologies in order to enhance Marine Corps learning (*TECOM Policy Letter 1-17*, 2017). The Future Learning Group leads TECOM's S&T initiatives working with partners to enable the Marine Corps to better capitalize on emerging opportunities to improve Marine Corps training and education. Since its establishment, the TECOM Future Learning Group has evaluated emerging simulation technologies, adaptive mobile learning technologies, and instructional methodologies in collaboration with S&T partners such as the Office of Naval Research (ONR), the Defense Advanced Research Projects Agency (DARPA), and the Advanced Distributed Learning (ADL) Initiative. Aside from "looking over the horizon" for emerging S&T that could significantly improve training and education, the Future Learning Group also looks to rapidly leverage scholarly, commercial, or other governmental investments for Marine Corps gain. In short, the Future Learning Group is helping TECOM to overcome the learning innovation barriers cited in the previous section, bridge the research–practice gap, find ways to help stakeholders better navigate the S&T processes within the Defense Acquisition System, and facilitate the organizational culture changes to encourage innovation.

Figure 1 shows three examples of capabilities tested by the Future Learning Group. First, the *Perceptual and Adaptive Learning Modules* (PALMs) is an adaptive, drill-and-practice learning application that uses perceptual learning methods, such as implicit learning and spaced practice. PALMs allows Marines to easily create "flash-card" content (with the learning theory already embedded), and learners can access the application via their computer or mobile web browsers (e.g., Thai, Krasne, & Kellman, 2015). Second, the *Personal eBook for Learning* (PeBL) is an extension to EPUB 3 that integrates support for various instructional methods, establishes a new infrastructure for the "Internet of books," and adds learner performance tracking into contemporary eBooks (Robson & Berking, 2017). Finally, the *Instructor Mastery Model* from the MInD initiative identifies factors associated with instructor expertise, rubrics, and technology-enabled learning tools for Marines to assess instructors along a path to skill mastery (Phillips et al., 2017). The Marine Corps has integrated the model into the *NAVMC 1553.1A Marine Corps Instructional Systems Design/Systems Approach to Training and Education Handbook*, which guides all Marine Corps learning programs and instructional interventions (Lukeman, 2016).



PALMs – Adaptive "Flash Cards"

PeBL – Next-Generation eBook

MInD – Instructor Development

Figure 1. TECOM Future Learning Group S&T assessments: (1) PALMs, (2) PeBL, and (3) MInD

Each of the aforementioned capabilities leverage learning science and offers lightweight, low-cost benefits for the Marine Corps. However, despite both the leadership and end-user demand signals for the capabilities, relatively low costs, and overall positive user feedback, transition of these sorts of learning capabilities has been slow. Consider, for example, implementation and transition of the PALMs application. It can run flexibly on common hardware, uses standard browser-based software, and requires no costly licenses for government-use. Nonetheless, its Service-wide implementation has been slowed by outmoded policies on learning applications and limited policy related to mobile learning. In August of 2017, the Future Learning Group and Training Command (a major subordinate command of TECOM) conducted a pilot assessment of the PALMs application with Marine instructors and students. A Marine instructor at the Marine Corps Communications Electronics School inserted learning content on basic symbols, terms, and concepts relevant to the Basic Electronics Course into PALMs for students who were awaiting seats in this course. Those students then used the PALMs web application on desktop computers twice a day in 15-minute increments for six days. Of the students who used the application, 97% responded that they "liked" using it, and 100% indicated that they believed that using the application would help their learning in their formal course. At the end of the course, 81% of students indicated that the PALMs application assisted their learning in their formal course and recommended that more materials be provided in the application. Additionally, students requested that they be allowed to access the content from the moment that they arrive at the schoolhouse. Since TECOM began to assess the prototype PALMs learning application less than a year ago, Marine end-users have created over 40 different Marine Corps learning content areas using the application's authoring tool. Although this was a limited military user assessment with subjective feedback, it demonstrates that Marines are interested in using these types of learning applications to create tailored learning content. If the Marine Corps integrates adaptive learning applications that tailor the content to students' needs to accelerate learning, a more substantial effect could be experienced across Marine Corps training and education. The reasons for such potential are clear: they are easy to use and intuitive for those who have grown up in the Information Age, they adapt the level of difficulty based on the user's responses, they allow students to proceed at their own pace, and they are more engaging than Industrial Age methods.

Finally, consider the ONR MInD example. The Marine Corps successfully transitioned the Instructor Mastery Model and methods into the Marine Corps handbook that guides all Marine Corps learning programs, and they are being used in instructor development programs. The MInD products were non-material solutions, which enabled the Marine Corps to more rapidly transition and implement the methods to enhance instructional programs. Additionally, the transition pathway for these instructional development knowledge products was clearly defined from experience with previous instructor development initiatives. These knowledge product–based solutions can serve as a launch pad for additional learning innovations, but they also rely on associated organizational behavior changes to affect the culture to effectively integrate the methods into established training programs.

Current Limitations and Challenges

Current DoD processes are not responsive to the rapidly changing training and education community needs—"the Department is over-optimized for exceptional performance at the expense of providing timely decisions, policies, and capabilities to the warfighter" (Mattis, 2018). Currently, there are lengthy approval chains and risk-averse processes that impede organizations from quickly implementing changes and obtaining new capabilities. For example, when discussing with acquisition professionals how to move ahead with an adaptive flash card-like training mobile application developed by a DoD S&T organization for implementation within Marine Corps training, training and education representatives were initially told that the mobile application would need to become a program of record

and it would take several years to implement. By the time that such a process is implemented, the software will be antiquated and potentially no longer relevant. The secondary recommendation was to work with partners across the United States Government to host the application in the cloud and enable the application to be available to other Government users. This of course assumes that the Marines have persistent access to wireless cloud services and communications within their training environments, and mobile devices that can access learning applications, which is currently not the predominant situation.

Senior DoD leaders and members of Congress have made impassioned calls for acquisition reform to enable the Department to more quickly provide modern capabilities to warfighters and the civilian workforce. There has been much dismay expressed in countless speeches, articles, and blogs regarding the slow pace of acquisition reforms and the high cost of fielding capabilities. Yet, little progress is seen in practice—despite the establishment of innovation advisory groups, the creation of innovation-focused organizations that identify technological innovations from non-traditional partners, and the establishment of more flexible acquisition methods, such as the Other Transition Authority (OTA; see Grady 2017 for the DoD *Other Transactions Guide for Prototype Products*). Although these interventions form a good initial step to address this challenging issue, they have yet to sufficiently resolve the enormity of the problem or the widespread concerns that the U.S. is neither effectively nor swiftly integrating innovative products into its programs. As a result, many innovative solutions continue to not reach end users at their points of need.

Although the *Summary of the National Defense Strategy* states that "The Department's leadership is committed to changes in authorities, granting of waivers, and securing external support for streamlining processes and organizations" (Mattis, 2018), many DoD professionals are reluctant to seek waivers and process changes. Many acquisition professionals implementing the Federal Acquisition System (Department of Defense Instruction 5000.1) seem resigned to the fact that obtaining new capabilities still takes many years, rather than months. Senior leaders rely on experienced acquisition professionals, who are generally averse to perceived risks, to implement the reforms – resulting in incremental rather than evolutionary improvements to the process and capabilities. Leaders have been calling for improvements to the defense acquisition system since the 1960s, with little success. However, the difference between today and the previous decades is that the acknowledgement that the current and future security environments and pace of technology change are quite different. The current security environment of peer adversaries with advanced technologies poses significant threats to the United States and allies, coupled with non-state actors that leverage readily available commercial technologies against our troops. The rapid development of technologies has provided both significant risks and opportunities for the United States. These developments, cited by senior leaders and experts alike, have increased the awareness that the United States needs to implement changes to the current DoD processes in order to revitalize a culture that embraces innovation and life-long learning, so that our forces are ready to defeat emerging threats in future operations.

Particularly for software products, an identified challenge is quickly providing innovative technologies to end-users at their points of need within current DoD processes. Federal acquisition processes can take years to complete, and in the fast-paced world of technology, that means that military end-users may not get the most updated software tools until the technologies are nearly obsolete. To enhance the way that DoD software products are developed and delivered, the DoD has created the Defense Digital Service (DDS), a Research, Development, Test, and Evaluation (RDT&E) program that intends to apply private sector best practices, skills, and technologies. Specifically, the DDS is to improve DoD cloud and information technology implementation practices and policies. The Defense Innovation Unit Experimental (DIUx) and Service-specific rapid capabilities offices have increased the utilization of OTAs, also referred to as "other transactions" (OTs), speeding up the contracting process and leveraging previously underutilized authorities granted to the DoD. The OTAs are a provision within Title 10 of the United States Code (specifically, 10 U.S.C. §2371b) that enables the DoD to "carry out prototype projects that are directly relevant to enhancing the mission effectiveness of military personnel and the supporting platforms, systems, components, or materials proposed to be acquired or developed by the Department of Defense, or to improvement of platforms, systems, components, or materials in use by the armed forces." This provision is available to streamline protype projects and to transition successes into follow-on production (Grady, 2017). The purpose of the OTAs are to spur innovation, attract businesses with leading edge technologies, and enable DoD to rapidly explore innovative prototypes to assess their applicability to military use. According to the USD (R&E), one of the second-order effects of DoD's implementation of OTAs has been "increased linkages between the contracting staff and the S&T mission," improving DoD processes (Griffin, 2018). Although there has been much excitement regarding the potential of leveraging OTAs to obtain innovative capabilities, there is currently limited evidence of their use for training and education capabilities – and ultimately, a more agile acquisition system is needed. To date, the Marine Corps has conducted some limited exploration of the use

of OTAs for platform-based capabilities, however, it has yet to explore OTAs for learning technologies. Although OTAs do not provide the full acquisition and fielding authority associated with programs of record, they could be further explored to acquire and assess prototype technologies, including new learning technologies, to determine their effectiveness and applications to DoD learning needs. The DoD needs a range of options that could help bridge the gap between the risk-averse, formal acquisition systems and the quickly developing technology community by enabling DoD organizations to quickly obtain and assess prototypes.

Current Opportunities

The National Geospatial Intelligence Agency (NGA) has found an alternate way to provide innovative software applications to end-users in less than two months – and in a process similar to the commercial "app store" model. In 2015, NGA created the Innovative GEOINT Application Provider Program (IGAPP), a secure platform similar to consumer app stores where national security community end-users can download a variety of pre-approved software applications. As of May 2018, the IGAPP app store has had more than 24,000 downloads and offers 58 different apps in its store, with another 35 apps in development (Corrigan, 2018). After NGA identifies the gap or problem to be addressed with the software, it works with partner technology developers in the private sector and academia to quickly build a software solution. Developers build and submit their software, which is then tested against government cybersecurity and procurement standards. If the software passes the vetting process, then it becomes immediately available in the app store and developers get paid per user download (Corrigan, 2018). Because the funding provided to developers is directly tied to how many people download their software applications, they have an incentive to provide innovative, user-friendly solutions, keep their software secure, and ensure that it is updated. The IGAPP has dramatically shortened the timeline for NGA to obtain new technology while also encouraging more software developers to participate. NGA has a partner that handles the legal responsibilities for IGAPP, which enables organizations to participate in the program and submit prototype products for approval without diverting many resources away from product development – which speeds the delivery of these software products to end users. Additionally, end users can quickly download the vetted software tools at their points of need. This app store model is a change from the traditional DoD acquisition process, incentivizing and prioritizing delivery speed and innovation. Implementing a process model like IGAPP for learning software technologies could help DoD more effectively and efficiently leverage innovative private sector S&T products.

The Marine Corps is making progress towards a Marine Air-Ground Task Force (MAGTF) Common Handheld (Snow, 2018). The MAGTF Common Handheld program identifies suitable commercial devices, customizes their software, and ensures they meet security standards. The initial MAGTF Common Handheld capabilities are aimed at applications, such as Command and Control (C2) and situational awareness tools—that is, not training or education applications. While a MAGTF Common Handheld integrated product team was established to advise the program regarding manpower, personnel, and training, their "training" advice focuses on how to use the system, rather than how to leverage it to support learning. The first MAGTF Common Handhelds are scheduled to be fielded to infantry squad leaders in fiscal year 2019. This hardware could also be used for mobile learning applications, and implemented similarly to the NGA app store.

The opportunity costs of not leveraging technologies to enhance training and readiness are difficult to determine, however, the slow pace of technology implementation results in lost opportunities to make training more effective and efficient. For example, Marine Corps Formal Learning Centers, or "schoolhouses," often have high printed reproduction requirements that could be reduced by leveraging mobile devices and software applications. Although the cost of reproducing student materials ranges across the schoolhouses, it can be as high as $100,000 annually at a single location. Furthermore, a recent initiative to provide one Marine Corps printed publication to all entry level Marines resulted in a $36,000 per year cost estimate for reproduction. If learning materials such as course manuals, course outlines, texts, and adaptive, interoperable mobile learning applications such as PALMs and PeBL were provided to students via mobile tablets, there would not only be reduced printing reproduction costs, but there would also be increased student learning opportunities, effectiveness, and efficiencies. Although there have been some limited Marine Corps efforts over the past few years where schools purchased e-readers or tablets for their students to use during the courses, wide scale implementation of tablet devices for learning has yet to occur due to the slow process of enabling wireless communication throughout schoolhouse campuses and the lengthy approval processes for acquiring and securing mobile devices.

CONCLUSION

The costs of not leveraging S&T to modernize learning systems and processes are clear. Without sustained and focused effort to implement learning science, technologies, and innovation—and a predictable funding environment to sustain them—the U.S. risks decreasing readiness and continued erosion of our military advantage. To reduce the risks associated with swiftly integrating emerging commercial learning technologies and best practices that may have limited evidence to support efficacy in military environments, DoD can acquire and assess the potential value of these capabilities within the current system by leveraging the S&T community, collaborating with partner organizations, providing frequent end-user feedback on prototypes, exploring processes such as creating government app stores for vetted software applications, and using OTAs to obtain and assess prototypes. Strengthening policies and an intrapreneurial culture in DoD that encourages increased innovation would assist the Services to better leverage S&T. Policies and processes that prioritize innovation and the speed of delivering the most agile, interoperable, adaptive, and extensible learning capabilities to warfighters would substantially enhance the ability of DoD learning systems to keep up with the pace of emerging training and education needs. Even so, the acquisition system needs to provide the Services with more agility to be able to identify and implement new learning technologies more quickly. Acquisition regulations that were originally designed to acquire the most effective ships, aircraft, and combat vehicles do not apply well to obtaining innovative and extensible learning systems. Leadership has called for such improvements – and it is incumbent on the training and education communities to identify how to best integrate them into programs.

To generalize the lessons learned from the Marine Corps examples and experience, it is widely recognized that the DoD needs to modernize its learning systems, and the results of the aforementioned S&T assessment examples support the premise that newer military members prefer technology-enabled personalized learning delivery methods. There are opportunities to more swiftly integrate and adapt emerging S&T into military training and education programs, for example, exploring how capabilities such as common handheld devices could be used for both operational and training purposes to deliver distributed learning at the end users' points of need. We can also leverage learning science, but it needs to be adapted to military use, working with practitioner end-users. Any successful implementation of learning S&T for the military needs to recognize the realities of military practices when evaluating the how to apply the research results. For example, the MInD program bridged the research–practice gap by working with the military practitioners to develop a Mastery Model for Marines to easily assess instructors' skills and progress in clear, easily understandable, and easily implementable tools. This kind of adaptation of learning science to military applications is a good way to apply scientific results to the military domain. In other words, there is an opportunity to adapt the learning S&T into tools that add value to end users, without expecting that they become learning scientists to understand and implement the materials.

RECOMMENDATIONS

Based upon our examination of transitioning low-cost prototype learning S&T to the Marine Corps, we have identified several recommendations for better facilitating the integration and implementation of such capabilities. It should be noted that these suggestions come from our firsthand experiences, not broad or controlled studies, and they represent our personal (not DoD official) perspectives.

(1) **To overcome the research-practice gap, support rapid prototyping, agile assessment, and frequent end user feedback.** DoD processes need to prioritize frequent end-user feedback, continuous adaptation of products to emerging needs , and modular upgrades to more quickly capitalize on emerging opportunities. Policy should encourage more agile processes to better leverage S&T and innovative capabilities to accelerate learning. For example, the TECOM Future Learning Group is exploring expanding collaborations with partner organizations to increase communication and provide operational end user feedback from early adopters - so that S&T prototypes will be more quickly integrated into Marine Corps programs and relevant to future training and education needs.

(2) **Explore best practices to overcome perceived acquisition system barriers and create integrated learning capabilities**. As military Services move towards developing an integrated learning "system of systems" or "ecosystem" of intelligent technologies, the products must be able to interoperate with existing legacy systems and allow room for the system to be extensible to address future training and education needs. These products need to add capabilities in the learning architecture along the continuum of learning and take into consideration future potential to modularly add to or integrate the capabilities to address

emerging needs, rather than remain stove-piped and unable to effectively, easily, or quickly address training needs. For example, the Marine Corps has a mix of legacy, sometimes proprietary, and new learning capabilities, which creates challenges for the Service to easily integrate the different learning capabilities into an interoperable, extensible learning ecosystem and conduct Live, Virtual, and Constructive (LVC) training exercises. The Marine Corps is exploring open learning architectures and product interoperability for extensible learning systems. Additionally, the Marine Corps exploring how to seamlessly integrate apps into learning programs. The DoD should further explore a development and distribution model similar to the NGA IGAPP model to expedite the development and deployment of software apps, and increase understanding of how to leverage opportunities to obtain prototypes using methods such as OTAs. Where possible, the DoD should explore the dual use of operational capabilities, such as common handhelds, for training purposes. Implementing dual-use capabilities would not only streamline systems, but also assist with integration and potentially assist with training transfer.

(3) **Strengthen collaboration between Government, academic, and industry partners to enhance innovation and speed of delivery.** To more efficiently and effectively integrate emerging S&T into military training and education programs, Service training and education organizations should prioritize speed of delivery and work more closely with traditional and non-traditional S&T partner organizations. Traditional and non-traditional S&T partners provide complementary capabilities that can improve DoD's understanding of the future learning environment, enable military Services to more quickly capitalize on emerging S&T, and expand the Department's options. The partner organizations can also provide access to critical emerging technology expertise, informing the Department's decision-makers and those charged to implement its processes to obtain needed capabilities.

(4) **Incentivize innovation and performance.** The national security community needs to update outdated management practices. Processes need to incentivize the DoD laboratories, academia, and industry partners to provide innovative capabilities more quickly to ensure that the Department has the most effective, integrated learning delivery systems rather than incremental improvements to stove-piped systems. The national security community should promote a government-wide software application store where end-user organizations would be able to obtain apps more quickly to support missions, tools could be quickly vetted and used across agencies, and it would promote increased software innovation and performance.

The Department's management structure and processes are intended to be means to support the warfighter with the knowledge, training, equipment, and systems to fight and win our nation's battles. As we transition from the Industrial Age models, we need *to better integrate and more swiftly adapt* Information Age capabilities for learning. Now is the time for DoD to consider the above recommendations and examine personnel management and acquisition processes that could substantially benefit from leveraging S&T to launch innovation in learning.

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