Improving Training through Human Systems Design in a Mobile Apps World

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ABSTRACT

The majority of Americans of US Military age own mobile devices such as smartphones. The small footprint applications on these mobile devices, commonly called "digital apps" or "mobile apps," are widely available and enable users to access information, play games, communicate with their friends and colleagues, purchase goods, and pay bills. As mobile apps continue to expand their presence in everyday life, the connection to military training is also taking hold.

This paper discusses the learning value of mobile devices and their ability to support learning and practice anytime and anywhere. By enabling learners to access instructional material in many forms (audio, visual), to remediate and practice skills independently and to support access to updated information immediately, these devices are revolutionizing education in our school systems. However; as with all revolutions, this one may come with a cost. This paper leverages recent research in learning and retention for specific militarily-relevant skill types to recommend the most effective way to integrate these devices and the mobile apps into instructional and practice programs for the military user. Additionally, this paper will discuss the trade-offs between enabling users to personalize applications and devices and the complications this introduces into instructional design. Finally, this paper will recommend a way forward for how best to implement the potential these devices offer in military training.

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INTRODUCTION

The growth in use of commercial mobile devices[1] and applications is astounding. In March 2012, a majority (50.4%) of U.S. mobile subscribers owned smartphones, up from 47.8 percent in December 2011. Smartphones are particularly popular among ages 25 to 34, which is squarely in the center of the military population. More than two out of three in this age group own a smartphone and each smartphone owner has an average of 33 applications ("apps") on their mobile phone, up 22 percent since 2010 (Nielsen, 2012). The most commonly downloaded and used apps are games, with retail shopping coming in a close second. This popularity of games on mobile devices clearly demonstrates that small devices can support a satisfying and productive user experience for adults of military age.

This evidence is crucial to the delivery of training, in which learner engagement has been shown to play an important role in the acquisition of skills that are important to military task performance, including critical thinking skills (Pascarella et al., 2001), cognitive and intellectual skills (Anaya, 1999), and problem solving skills (Johnson, Johnson, & Smith, 1998).

Given the proliferation of mobile devices and the ability of apps on this device to deliver an engaging experience, there is ample motivation for the US military to consider mobile applications as an affordable method to deliver training to warfighters. As we discuss later in this paper, it is clear that this is already occurring.

However; in order to fully exploit the promise of mobile platforms, several questions need to be answered with regard to how these devices can be used to optimally support learning and retention of military skills. We must broaden our thinking of how to equip our warfighters with usable and useful devices that work in a military environment and we must look to our training research community to help set guidelines for how to deliver content that enables warfighters to learn and practice skills. Finally, in order to fully leverage the burgeoning mobile app development community, the US military must achieve a business transformation of sorts.

This paper makes an assumption that the U.S. military is and will continue to invest in mobile applications development. This is supported by statements from senior government officials such as "The use of Digital/Mobile Applications for training will be prolific across the Army in support of both combat and non-combat operations"(Marion 2011). The focus of this paper is towards the ways to best implement mobile apps for training and not directly to validate the rationale or benefits of mobile apps as a training tool. Our paper begins with a discussion of the current state of mobile devices and apps in the military, and briefly discusses a few operational and training applications that are underway. Then, the paper identifies relevant research findings that can be leveraged to guide the further application of mobile apps in delivering effective military training and practice opportunities. These research findings are typically linked to training delivery methods and could potentially trigger Human Systems Integration (HSI) and usability challenges, so in the next section of the paper, we discuss the practical HSI tradeoffs associated with implementing the recommendations from the research. Finally, the paper recommends a path forward by identifying specific research gaps that our community should address and by presenting some ideas for mitigating the realities of the military acquisition process that potentially restrict our ability to fully leverage the benefit of mobile apps.

CURRENT STATE OF MOBILE DEVICES AND APPS IN THE MILITARY

Most of the handheld devices in operational use are heavily optimized for a particular task and are ill-suited for general-purpose use. For example, a soldier's radio has very limited data capability and essentially no multimedia capability. Similarly, current language

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[1] For the purpose of this paper, we define a **mobile device** as a small, hand-held computing device, having a display screen with touch input and/or a miniature keyboard and weighing less than 2 pounds (0.91 kg).

translation devices support neither messaging nor collaboration of any form. Even efforts to develop multi-functional devices hold true to this characterization. An example of this is the US Army's Common Controller (CC). While the CC does provide networked communication capabilities and consolidates command and control functions, it is still tightly constrained to supporting selected soldier functions (medical, logistics, maintenance, etc.) on unmanned vehicles.

This is in stark contrast to the commercial business model, in which devices are typically valued by the number of features and functions they support. In addition to performing as a communication device, today's simplest smartphones include a calendar and calculator, supports web browsing and games, and enables the user to view maps, navigate, play music and take photos.

Important military requirements (e.g., security, battery life, ruggedness) necessarily dominate the design of hardware and software that are intended to support *operational* mission performance. These requirements inhibit the ability to leverage the vast creative and innovative commercial mobile device and app developer community.

Apps that are designed to provide training are a much easier sell. The challenges of security, information assurance, and suitability for the environment are significantly more manageable when the app and the delivery platform are intended to be used outside the real-time mission context. This difference, coupled with the promise of benefits to learning and retention, provides ample motivation to examine the case for integrating these tools into a capability to deliver military training. This use case is the focus of the remainder of this paper.

The idea of using mobile apps to deliver and/or supplement military training is not new. In fact, the Army Capabilities Integration Center (ARCIC) has launched a program called Connecting Soldiers to Digital Apps (CSDA). One of the elements of the CSDA approach is to evaluate COTS and customized mobile apps for their usefulness. Specifically, CSDA is working with the Army's Network Enterprise Technology Command (NETCOM) and the Army's Chief Information Officer to determine how best to secure data being accessed by these devices. As part of this work, the Army Evaluation Task Force has evaluated both military-developed and commercially-developed apps, and has examined mobile apps to supplement existing training efforts. Some examples include applications that support First Aid and Land

Navigation modules in the Basic Training common core lessons and training content for the NCO Advanced Leader Course.

In the medical realm, the military is using mobile apps to support Traumatic Brain Injury (TBI) treatment, and to provide access to behavioral health resources [1]. These apps enable users to monitor their aspects of their own mental health by providing scales to measure and track anxiety, stress, depression and general well-being. While this is a broader interpretation of "training" than we typically use, these apps are used to sensitize (or "train") soldiers to recognize symptoms of their mental health and to apply specific techniques to improve their state.

Additionally, Army.mil has published and made available a number of mobile apps mainly aimed at improving access for soldiers and their families to Army social media sites and to provide links to Army services. In addition, these apps include single point access to simple reference material (ranks, uniform, Army song, etc.). Perhaps most importantly, these apps are available through the Apple App Store.

In the next section we present relevant research findings that could improve our ability to achieve training benefits from mobile apps.

LEVERAGING RESEARCH TO IMPROVE THE APPLICATION OF MOBILE APPS

Traditional military training is highly organized and relies on instructors to ensure that students are progressing appropriately and achieving proficiency. Military leaders rely heavily on the reliability of the existing training system and the predictable process implemented through Programs of Instruction. To successfully integrate mobile apps into this culture, the community must acknowledge this reality and provide proven and demonstrable performance benefit (e.g., improvements in learning and retention rates).

Since very few research studies have been conducted to determine the effectiveness of mobile apps on learning and retention on military-type tasks, to assess this likelihood we must look to the research on computer based training (CBT) and Online Learning. The common elements of these contexts are that training content is delivered through a mechanism with similar *functional* capabilities to a mobile device (e.g., ability for students to self-pace, opportunity for the course progression to adapt to the student's performance, selective levels of feedback, personalized remediation).

Fortunately, there is evidence these functional capabilities can be brought to bear in a way that accelerates learning rate (i.e., time to proficiency) and improves retention, resulting in affordable and measurable improvements to warfighter performance. In fact, most studies have found CBT/Online Learning to be equally, if not more effective than traditional classroom instruction.

There are several examples of successful CBT implementations to support military tasks:

- The SHERLOCK tutor trained aviation technicians who produced significantly fewer errors than controls (Lajoie & Lesgold, 1992). Subjects who spent twenty to twenty-five hours using SHERLOCK were as competent at troubleshooting as technicians with four more years of job experience.
- An Intelligent Tutoring System (ITS) for the assembly of the SINCGARS radio system used photo-realistic images, an interactive conceptual model, and alternative forms of coaching to produce significantly improved performance (Orey, Zhao, Fan, and Keenan (1998).
- The Virtual Sand Table used computer based instruction and feedback to produce a 1.05 Standard Deviation (SD) improvement in artillery training (Wisher, Macpherson, Abramson and Thornton, 2001).

The findings of these CBT studies support our contention that mobile app-delivered military training can deliver performance improvements, if properly composed. With acknowledgement that properly composed mobile apps are useful in training we have identified three potential areas for application of mobile apps in military training, web based instruction, combat skill decay, and skill mastery.

Mobile Apps to Support Web-Based Instruction

Mobile apps can be designed to provide instruction across a spectrum of training modes, including web-based instruction in which the app is a portal to a web service. In this context, Means, Toyama, et al. (2009) conducted a literature review and meta-analysis focused on studies of Web-based instruction. They included only studies with random-assignment or controlled quasi-experimental designs. They examined effects for objective measures of learning. Fifty-one study effects were included. The main findings from the meta-analysis were:

(1) Students who took all or part of their class online performed better, on average, than those taking the same course through traditional face-to-face instruction. Learning outcomes for students who engaged in online learning exceeded those of students receiving face-to-face instruction[2].

(2) Blended instruction combining online and face-to-face elements had a larger advantage relative to purely face-to-face instruction than did purely online instruction[3]. This advantage is larger than that for studies comparing purely online and purely face-to-face conditions[4].

While these results indicate that online learning and blended instruction seem to show advantages over traditional classroom instruction, review of other studies show that online learning is not necessarily the superior medium.

In fact, Galvis, (2008) conducted a literature review and meta-analysis comparing the effects of computer-assisted instruction with traditional teaching methods within the health care education field. His meta-analysis included nineteen studies with two of those studies reporting two separated sets of data, totaling 21 sets of data, or cases. He determined that 52% of the cases had no difference between Computer Assisted Instruction (CAI) and other types of instructional method.

Across both meta-analyses, studies' conditions differed in time spent, curriculum, and pedagogy when comparing online and classroom instruction. Thus, potential learning advantages are a combination of the elements in the treatment conditions. However, although the method of online learning may not be the direct cause of the learning differences, if mobile apps can facilitate more time spent, better curriculum or pedagogy, then they are likely to improve performance. More simply, these findings indicate that mobile apps are likely to be most effective when used to supplement classroom instruction; however the performance advantages will not come automatically and attention must be paid to course design.

Mobile Apps to Combat Skill Decay:

Conventional wisdom holds that mobile apps might be best suited to support retention of highly perishable digital skills (Johnston, Leibrecht, Holder, Coffey, and Quinkert, 2003); however, there are conflicting

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[2] The average effect size was a Hedges g = +0.24 favoring online conditions.

[3] The mean effect size in studies comparing blended with face-to-face instruction was a Hedges g = +0.35, p < .001.

[4] Average effect size of Hedges g = +0.14, p < .05.

empirical data documenting the rate or extent of skill decay (Goodwin, 2006). Schaab and Moses (2001) reported non-experimental data suggesting only small skill decay for soldiers using the All Source Analysis System (ASAS) after two months. And two individuals scored an average of 78% after one year. On the other hand, in a controlled study of overlay and report skills using the Inter-vehicular information system (IVIS), a vehicle mounted digital system that pre-dates Force XXI Battle Command Brigade and Below (FBCB2), Sanders (1999) found a 52% drop in overlay task proficiency and a 23% drop in report task proficiency after a 30 day no practice retention interval.

Goodwin also found evidence that the level of original learning is the training variable that best predicts the retention rate, so mobile apps should be considered as a component of an integrated training approach, rather than just a platform to practice skills that were already mastered.

Mobile Apps to Achieve Mastery

In terms of how to achieve mastery, there is a dearth of research that measures the ability of learners to perform a mastered task in a "far transfer" environment. That is, it measures the ability of the student to perform learned skills in a novel task environment by applying general concepts rather than strict procedures. This is a very important leap for the military training community, as the performance environment nearly always differs significantly from the learning environment.

The Army Research Institute (ARI) has been investing in basic research focused on how best to integrate desktop computer-based training tools into military training with a specific emphasis on improving performance on far transfer tasks. Their research varies training method (e.g., scaffolding, massed practice, exploratory learning) by task type, with an expected outcome of "best practice" findings for training designers. Some emerging results that are relevant to effectively integrating mobile apps into military training include:

- Highly structured training is good for near transfer but more exploration-based learning approaches can improve learning outcomes and facilitate adaptive transfer (e.g., Bell, Bradford and Kozlowski, 2008).
- The error prevention technique called "worked examples" (Renkl, Stark, Gruber, & Mandl, 1998) may be more effective for providing a problem schema for use as initial guidance. This method appears to be most effective for lower complexity

problems and near transfer tasks (Wickens, Hutchins, Carolan and Cumming 2011).
- Part Task Training can be successful if the integrated parts are varied in the priority they are given to the learner (Wickens, et. al 2011)
- Less structured training methods that require more learner effort can yield higher performance during transfer, especially transfer to new problem situations (Schmidt and Bjork, 1992).
- Increasing the difficulty of the training task is successful if the increases are adaptive. (Wickens, et. al 2011).
- Methods that involve active exploration with explicit encouragement for learners to make errors during training and to learn from the errors are likely to be most effective for adaptive transfer tasks that require the application of learned skills to a structurally new problem or task (Keith & Frese, 2008).
- Even first generation computer-based tutors have been shown to improve training effectiveness by 0.3 SD to 0.48 SD (Corbett, 2001). More recently, a five-year evaluation showed that using the Andes homework tutor produced an average 0.61 SD improvement for hour exams and an average 0.16 SD improvement for final exams. Andes provides immediate feedback, continuous scoring, and help options but did not use model tracing (VanLehn et al., 2005).
- Azavedo and Bernard (1995) performed a meta-analysis and their results indicate that the diagnostic and prescriptive management strategies of computer-based adaptive instructional systems provide the most effective feedback.

These results all have implications for the design of mobile apps and for the integration of app-based modules into the training program. For example, one aspect that is easiest to manage in a mobile app environment is how and when feedback is provided to the learner. The final bullet above guides us to value mobile apps that verify the correctness of the learner's answer and the underlying causes of error. This requires a reasonably robust student modeling capability, and is one of the HSI implementation topics we discuss in the next section.

HSI IMPLICATIONS FOR IMPLEMENTATION

As with other systems that are procured and deployed to deliver military training, we must attend to ensuring the mobile app fits the needs of the military population. In this section we address three key HSI factors for implementation of mobile digital apps, usability, personalization, and student modeling.

Usability

A dominant theory relating to training complex tasks and managing learner effort and workload is cognitive load theory (Sweller, 1988; Paas & van Gog, 2009). This theory holds that in order for learning of difficult tasks to occur, instruction must reduce the effort associated with working memory, in order to facilitate the changes in long term memory need to internalize the underlying structures that permit us to perceive, think, and solve problems. When interpreted in the context of mobile app usability, this has implications for the number of features in the app.

It is our experience that the best mobile apps are those with a tight, coherent design. Unlike desktop applications that suffer from "featuritis," good mobile apps usually are designed to perform a very specific task and they do that defined task very well. They promise specific functionality and deliver on that promise. As end-users, we are happy with constraining the functionality tightly (e.g., a video player, a game, or a portal to a larger website) because we are comfortable with the concept of having a library or portfolio of apps. They are cheap and easy to come by, so we don't worry that all our requirements are met in a single package.

More traditional discussions of usability in a military environment also include considerations of weight, battery life, visual signature, etc. and are tightly aligned with the HSI personnel survivability domain. We do not address those here since we are confining our discussion to the application of mobile apps to training and do not discuss design considerations that apply to using mobile apps in real time in an operational context.

Personalization

Unfortunately, mobile apps are just as easy to discard as they are to acquire. And in order to maximize the learning benefit of the apps, we must capture and retain the learner's attention. Therefore, the user interface must be rich, fast, interactive, and in an ideal world, personalized. This extends beyond user-definable tones, colors, logos, and layouts, to interface preferences (e.g., typing vs. speaking). The apps must leverage the capabilities of the mobile platform (e.g., shaking, turning, high resolution displays, speech interfaces).

The obvious trade-off is that enabling the learner to select not just the mobile device, but to also customize the look and feel of the interface provides challenges to the user-support staff that provides documentation, installation and other services. But in the mobile app world, users have come to expect this level of personalization and it is elemental to user satisfaction. Ideally, each warfighter would be free to shop around an app marketplace to select and use those apps that were most appealing and offered the most relevant instruction and practice for a particular warfighter's specialty or job. This would require a level of tolerance for individualized and self-directed instruction that would challenge any military training model, but is central to maximizing learning, as noted in the previous section.

Most importantly, this level of personalization probably requires we rethink our procurement business model. We discuss this further later in this paper.

Student Modeling

One of the most compelling reasons to adopt mobile apps is the potential for providing affordable and adaptable tutoring.

There are nearly 30 years of research that links good tutoring to improved performance. Bloom (1984) reported that students working with a "good" human tutor obtained achievement levels that were two standard deviations higher than students in conventional instruction. Even if we fall short of Bloom's "good" tutoring model, significant benefits are likely. In the classroom, peer tutors have been found to increase learning effectiveness by 0.4 SD (Cohen, Kulik and Kulik, 1982).

These results indicate a likely link between the sophistication of the embedded tutoring capability and performance. Therefore, the ultimate goal is to design mobile apps for training that are as effective as individual human tutors, but that can be widely disseminated. Since one aspect of human tutoring thought to be important is the ability to adapt to the particular needs of a student, this is a very high priority element of mobile apps.

In terms of tradeoffs, the simplest version of this is recommending apps for particular military specialties and relevant periods of the warfighter's more formal training. This is a relatively easy task, only requiring the mobile app library to be properly indexed by specialty (MOS, AFSC or NEC) and have a method of exposing the learning objective. For example, in the portion of the library for Infantry, under Land Navigation skills, the learning objective might be "Given a military map, a lensatic compass, and a minimum of an eight digit grid coordinate, locate specific points on the land navigation course."

We can imagine a broad spectrum of personalization, however, topping out with sophisticated knowledge management systems and embedded intelligent tutoring algorithms. The benefit for this investment is likely to be found in better performance. In fact, highly structured and traditional training methods (e.g., low variability practice, complete guidance, immediate corrective feedback), that are effective for skill acquisition as measured by learning criteria are less effective or even detrimental to transfer performance (Schmidt & Bjork, 1992). We can envision mobile apps as a way to provide variable practice and adaptive guidance and feedback. These capabilities are easily possible with today's technology.

PATH FORWARD

There are two important paths forward to discuss. The first is in performing research that assists us in prioritizing capabilities for mobile apps that maximize learning and retention. The second is to define an innovative business process that enables the DoD to benefit from the culture that surrounds the mobile app development community.

Research Gaps

The training research community has been immensely productive for decades. And, as identified earlier in this paper, some of that research is applicable to the designing and selecting mobile apps. However; some important gaps must still be filled in order to maximize the potential of these tools.

First, there is a lack of quantification and consistency in effectiveness measures. This gap makes it very difficult to conduct meta-analysis with significant effect sizes, and limits our ability to compare results of studies.

Second, little research has been performed to codify and clarify the relationships among training factors, task characteristics, and effectiveness measures. A contributing factor to this is the lack of a common framework. Several conceptual models have been proposed (e.g., Carolan, Belanich, McDermott, Hutchins, and Wickens 2011), and the research community would benefit from the adoption of a common framework.

Third, research is needed on the unique aspects of mobile devices. It is not clear yet how the use case of these devices (i.e., anytime, anywhere) impacts learning. In addition, it is not clear how the level of fidelity available on a mobile device can best be exploited to train or practice a military task.

Finally, and perhaps most importantly, the relationship between performance in a training environment and performance on a far transfer task is not well understood. Admittedly, these studies are difficult and more costly to perform, however; this knowledge is central to driving decisions on how best to present training, particularly when an instructor is not present to translate the training environment to the real world.

Business Process Considerations

In the current fiscal environment, every new initiative must be supported by a strong case for affordability. Certainly, the promise of mobile apps is associated with an open and unstructured marketplace that benefits from competition, ultimately driving prices down while driving innovation and performance up. This vision can only be achieved through the adoption of business processes and acquisition models that support such a marketplace.

Unfortunately, the most comfortable path forward for the DoD to acquire mobile apps would be through the traditional acquisition process, in which a requirements definition phase would be followed by a formal Request for Proposal, followed by proposals from industry, followed by source selection and contract award, and so on. This current DoD acquisition process is not well suited to the fast-moving, entrepreneurial flavor currently enjoyed by the mobile apps development community. In order for the DoD to fully leverage the capabilities of that community, the acquisition process will need to accommodate a much faster pace from requirements to delivery in weeks and streamline procurement that reduces proposal paperwork in favor of mobile digital apps delivery.

It would be possible to incentivize developers to contribute to a military training "app store" that enables them to retain the IP of their apps. In this marketplace, they would compete for warfighter's purchases, perhaps through some sort of voucher system. This could work much like the current Apple or Android marketplaces that include ratings that indicate the best apps coupled with on-line user reviews, ultimately driving sales volume and stimulating innovation.

An example of how this might work can be found at "iTunes U," touted as the world's largest digital catalog of free education content. Providers to this repository are provided guidelines that help them to develop and organize content. These guidelines discuss everything from how to provide appropriate metadata to how to include good artwork and overall design (Apple, Inc., 2011). Guidelines could also direct users to public documents that describe military tasks (e.g., Soldier's

Manual of Common Tasks, STP 21-1-SMCT) so that the developer community could use military terminology appropriately and so they could describe their learning objectives in terms that make sense to the military consumer.

Another example of an innovative approach to mobile app acquisition is the inaugural Science, Technology, Engineering, and Mathematics (STEM) App Challenge being hosted by the Office of the Under Secretary of Defense for Personnel and Readiness (OUSD P&R) Advanced Distributed Learning (ADL) Initiative. The STEM App Challenge seeks to identify innovative mobile applications that address STEM learning for grades 9-12. Each competitor must identify a problem statement and learning solution. The winners will be selected on how well they solve the problem, technical quality (i.e., ease of installation, graphics, sound, presentation), usability and innovativeness. Winners retain ownership of their IP, provide unlimited licenses for DoD Education Activity student use, and receive publicity and promotional rights for their app.

If there is sufficient interest in opening the marketplace to a broad, potentially worldwide, community of mobile app developers, then there are obvious issues associated with security. While several militarily relevant skills can be learned and practiced in apps that are devoid of militarily-specific content (e.g., pattern matching, map reading), it is certainly safe to presume that some portion of the apps would include military content. Therefore, we must find methods to guard against mobile apps that would negatively impact transfer of training. As an example, military processes and procedures, even if unclassified, change regularly enough that a mobile app could become outdated.

For this and related reasons, it is probably worthwhile to accept that military training organizations will need to review the content of the mobile apps before they are accepted into the repository. We can again look to the commercial marketplace for models of how to manage this process, but it would almost certainly include a commitment from the Services to review apps to ensure the content is accurate and unclassified.

SUMMARY

This paper leverages findings from the literature on learning and retention to make the case that mobile devices and the apps that reside on them can be leveraged to provide affordable and effective learning for the military. The capability to personalize the device, its ability to support exploratory learning and adaptive feedback and the accessibility to military population all contribute to this case.

However; to maximize the promise of these devices, an effort must be made to provide relevant and actionable guidelines to the developers to avoid negative transfer. These guidelines must extend from how to employ training methods most effectively (e.g., how to ensure that Part Task Training improves Whole Task performance) and that the military content of the training is accurate.

Key to success, however; is the design of a business process that will bring these solutions to military users in ways that make them engaging and fun to use.

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REFERENCES

Anaya, G. (1999). College impact on student learning: Comparing the use of self-reported gains, standardized test scores and college grades. Research in Higher Education. 40, 499–526.

Apple, Inc. (2011). http://deimos.apple.com/rsrc/doc/ iTunesUAdministrationGuide/AboutiTunesU/chapter _3_section_1.html#//apple_ref/doc/uid/AdminGuide-CH2-SW1.

Azevedo, R. & Bernard, R. M. (1995). A Meta-Analysis of the Effects of Feedback in Computer-Based Instruction. Journal of Educational Computing Research, Vol. 13 (2), 111-127.

Bell, Bradford S.; Kozlowski, Steve W. J. (2008). Active learning: Effects of core training design elements on self-regulatory processes, learning, and adaptability. *Journal of Applied Psychology, 93*(2), 296-316

Bloom, B. (1984). "The 2 Sigma Problem: The Search for Methods of Group Instruction as Effective as One-to-One Tutoring", Educational Researcher, 13:6(4-16).

Carolan, T., Belanich, J., McDermott, P., Hutchins, S., & Wickens, C. (2011). *Investigating the Impact of Training on Performance*. Paper No. 11306. Proceedings of the Interservice/Industry Training, Simulation, and Education Conference (I/ITSEC).

Cohen, P., Kulik, J., & Kulik, C. (1982). Educational outcomes of tutoring: A meta-analysis of findings. American Educational Research Journal, 19 (2), 237-248.

Corbett, A. (2001). Cognitive computer tutors: solving the two-sigma problem. In A. Jameson, C. Paris & C. Tasso (Eds.), User modeling: Proceedings of the

Sixth International Conference, (327-337). New York, Vienna: Springer Wien.

Galvis, A. (2008). Computer-assisted instruction (CAI) as a teaching tool for occupational therapy education: A guide to understand CAI design and effectiveness. Dissertation Abstracts International, 68 (07), 2907A. (UMI No. 3271416)

Goodwin, G. A. (2006). The training, retention, and assessment of digital skills: A review and integration of the literature (ARI Research Report 1864). Arlington, VA: US Army Research Institute for the Behavioral and Social Sciences.

http://health.mil/MHSCIO/news_resources/portal/March 2011/i-phone-apps-tackle-TBI-combat-stress-anxiety.aspx

Johnston, J. C., Leibrecht, B. C., Holder, L. D., Coffey, R. S., & Quinkert, K. A. (2003). *Training for future operations: Digital leaders' transformation insights* (ARI Special Report 53). Alexandria, VA: U.S. Army Research Institute for the Behavioral and Social Sciences.

Johnson, D. W., Johnson, R., & Smith, K. (1998). Active learning: Cooperation in the college classroom. Edina, MN: Interaction Book Company.

Keith, N. and M. Frese (2008). Effectiveness of Error Management Training: A Meta-Analysis. Journal of Applied Psychology.

Lajoie, S.P. & Lesgold, A.M. (1992). Dynamic assessment of proficiency for solving procedural knowledge tasks. Educational Psychologist 27 (3), 365-84.

Marion, P. (2011, March 16) Mobile Applications – Army's Directions and Our Challenges. AFCEA, Orlando, FL.

Means, B., Toyama, Y., Murphy, R., Bakia, M., & Jones, K. (2009). *Evaluation of Evidence-Based Practices in Online Learning: A Meta-Analysis and Review of Online Learning Studies*. Available from the U.S. Department of Education at http://www.ed.gov/rschstat/eval/tech/evidence-based-practices/finalreport.pdf .

Nielsen (2012). Nielsen's State of the Media: The Mobile Media Report. http://www.nielsen.com/us/en/insights/reports-downloads/2011/state-of-the-media--mobile-media-report-q3-2011.html.

Orey M.; Zhao R.; Fan H.-L.; Keenan R. (1998). "Summative evaluation of the SINCGARS Tutor" in Computers in Human Behavior, Volume 14, Number 4, 1 December 1998 , pp. 579-595(17).

Paas, F., Van Gog, T. (2009). Principles for designing effective and efficient training of complex cognitive skills. In Durso, F. T. (Ed.), *Reviews of human factors and ergonomics, 5* (pp 166-194). Human Factors and Ergonomics Society.

Pascarella, E. T., Palmer, B., Moye, M., & Pierson, C. T. (2001). Do diversity experiences influence the development of critical thinking? Journal of College Student Development, 42, 257-271.

Renkl, A., Stark, R., Gruber, H., & Mandl, H. (1998). Learning from worked-out examples: The effects of example variability and elicited self-explanations. *Contemporary Educational Psychology, 23,* 90-108.

Ross C. Teague, Stuart S. Gittelman, and Ok-choon Park (1994). A Review of the Literature on Part-Task and Whole-task Training and Context Dependency. ARI Research Report 1010. Alexandria, VA. U.S. Army Research Institute for the Behavioral and Social Sciences.

Sanders, W. R. (1999). Digital procedural skill retention for selected M1A2 tank intervehicular information systems (IVIS) (Research Report 1432). Alexandria, VA: U.S. Army Research Institute for the Behavioral and Social Sciences.

Schaab, B. B., & Moses, F. L. (2001). *Six myths about digital skills training* (ARI Research Report 1774). Alexandria, VA: U.S. Army Research Institute for the Behavioral and Social Sciences.

Schmidt, R. A., Bjork, R. A. (1992). New conceptualizations of practice: *Common* principles in three paradigms suggest new concepts for training. *Psychological Science, 3,* 207-217.

Sweller, J., Cognitive load during problem solving: Effects on learning, Cognitive Science, 12, 257-285 (1988).

VanLehn, K., Lynch, C., Schulze, K., Shapiro, J. A., Shelby, R., Taylor, L., Treacy, D., Weinstein, A., & Wintersgill, M. (2005). The Andes physics tutoring system: Lessons learned, International Journal of Artificial Intelligence in Education, 15(3).

Wickens, C.D., Hutchins, S., Carolan, T., & Cumming, J. (2011). Investigating the Impact of Training on Transfer: A Meta-Analytic Approach. Proceedings of the Human Factors and Ergonomics Society 55th Annual Meeting. 19-23 September, Las Vegas, NV.

Wisher, R.A., Macpherson, D.H., Abramson, L.J. and Thornton, D.M. (2001). The Virtual Sand Table: Intelligent Tutoring for Field Artillery Training. Research Report #1768. US Army Research Institute for the Behavioral and Social Sciences.