ABOUT THE MEETING

"ACCELERATED LEARNING AND FACILITATED RETENTION OF PROFICIENCY"

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Introduction

The objective of this effort is to create a design and roadmap for investigations aimed at developing robust and broadly-applicable methods for:

(1) Accelerating the achievement of proficiency in USAF mission-critical specializations (and analogous domains in the private sector), and
(2) Facilitating the retention of knowledge and skill, especially for military personnel who must take long hiatuses from their domain of primary expertise in order to fulfill other military requirements.

USAF personnel, especially officers, are required to leave those domains to perform duties such as staff duty, teaching at a military academy or in Reserve Officer Training Corps programs, and taking courses of study at military or civilian institutions of higher education. These hiatuses can last from a few weeks to as long as four years. During these hiatuses it often not possible to train or practice in their domain of primary expertise.

Proficiency is critical to performance in complex work contexts, including the transformed strategic environment that confronts the USAF. During the Cold War, USAF personnel could typically count on staying in one place for assignment for at least three years before rotating. That era allowed for robust continuous training while at a duty station. However, in this current era of frequent deployments to a variety of locations worldwide to fight the War on Terror, there are far fewer opportunities to have systematic training and practice. Yet, it still ordinarily takes many years to achieve proficiency. Therefore, there would be great advantages if the USAF could establish regimens of training that could accelerate the achievement of that proficiency. There is reason to hypothesize that the achievement of proficiency can be accelerated, and the proposed working meeting will generate specific plans and roadmaps for actual attempts to do so. It is likely that methods for acceleration will leverage the technologies and capabilities including virtual training, cross training, training across strategic and tactical levels, and training for resilience and adaptivity.

The proposed working meeting would enable and support a larger-scale effort to culminate in a robust and broadly-pplicable suite of methods for facilitating the achievement and retention of proficiency.

Background

A workshop sponsored by the Office of the Director, Defense Research and Engineering and the DoD Accelerated Learning (AL) Technology Focus Team (July 2008) brought together leading academic, private sector, and DoD specialists in areas of training and expertise studies,

to discuss the goal of accelerated learning. Presentations at that workshop laid out the major challenges and issues for accelerated learning, and the activities proposed here will extend and refine the results of that effort, along with an initial "road-map" for investigations in mission-critical areas of the Air Force. In addition, the challenge of competency retention for personnel taking hiatuses will be explored.

While many military jobs can be trained through established COTS methods, and those tasks can be performed by journeymen, the military needs highly proficient personnel who can perform tasks. The bottleneck for producing such critical individuals is that it has typically taken many years of experience and deliberate practice for individuals to master their domains (e.g., anti-submarine warfare; see Ericsson et al., 2006). Reasons for this include domain complexity, irregularity across encountered cases, the need for deliberate practice, and the need for practice at tough cases to stretch skill.

Domain specialists provide technical judgment to speed decision-making in time-critical events. They provide resilience to operations by resolving tough problems, anticipating future demands and re-planning, and acting prudently by judgment rather than by rule. Specialists exercise effective technical leadership in ambiguous or complex situations, often by communicating subtle features that other people will not see until they are pointed out (Hoffman, 1997). Often they are also the ones who understand the history, the interdependencies of units and processes, and the culture of their complex organizations, knowledge that is often essential in actually "getting things done" (e.g., Stein, 1997).

The challenge of learning is compounded in the military by such practices as collateral assignment, frequent redeployment (e.g., rapid skill decay on the part of pilots creates a need for expensive re-training), inadequate or ad hoc mentoring, and the drive for “just-in-time” training. Another significant challenge is clustered around career (versus job) training, and expertise retention. Professional Military Education offered by such intuitions as the various war colleges is an example of career training. There personnel learn about operational and strategic warfighting issues. Indeed, the entire field of “knowledge management” is formed around the notion of preserving and sharing expertise (e.g., Becerra-Fernandez, et al., 2004).

Transfer, or the ability to use knowledge flexibly and effectively across application areas, is an important component of proficiency. In large respect, accelerated learning means improving transfer (and retention) capability. The major theory of transfer in learning is the "common elements" theory. Based on this idea, one would say that training should minimize the transfer distance from training to workplace. Recent research is suggestive of the conditions that promote transfer, such as the judicious use of particular kinds of feedback (Schmidt and Bjork, 1992). For instance, summary feedback is less conducive of initial learning than feedback after each trial, but summary feedback during learning does seem to promote delayed retention.

Performance issues go beyond transfer from the classroom to the operational context. Simply “working at a job” does not promote progression along the proficiency continuum (e.g., Feltovich, Prietula, and Ericsson, 2006). Unless there is continuous deliberate practice and feedback at difficult tasks, the only thing one can do “on the job” is forget and actually experience degradation of skill.

Furthermore, the current challenges for military training involve two different sorts of transfer. One is *transfer across mission types*. An example would be an infantry commander, who knows traditional warfare, who is asked to develop tactics for an insurgency operation. The second challenge is transfer across responsibilities. An example would be a warfighter having a skill at maintenance of an F-16 engine who is promoted to a supervisory position. Since different skill sets would be involved, one would need to train for the new role, and not just assume transfer would or might happen. When a journeyman or expert moves from a job where domain expertise is all that is required of them to a supervisory job, there is extra challenge because they are still expected to maintain their domain competence while also acquiring and performing their new supervisory skills.

The 2008 Workshop successfully pointed to capability gaps. The challenge now is how to a structure research questions and a research strategy to help the military address the gaps. Suggestions for acceleration methods include leveraging:

- The important features of deliberate practice and mentoring,
- The technologies of virtual reality training,
- Multi-media for training at complex tasks,
- Computer technology to develop and manage libraries of representative and tough tasks,
- Computer technology to develop and manage knowledge bases that capture expert knowledge and skill, and
- New cognitively based methods for designing instruction.

The technical research community is now positioned to work specifically on the question of how to create robust methods to accelerate the achievement of proficiency and facilitate its retention. Such objectives are the focus for a follow-on Working Meeting on Accelerated Learning and retention of competency that is the core component of the project we are proposing.

Retention Issues

An important part of the workshop is devoted to the reacquisition and retention of competence we relate below some key principles of learning retention. These principles from the literature are key for understanding retention for short term hiatuses from the domain of interest (e.g., weeks or months). However, there is very little literature and even less data about the types of long term hiatuses (up to four years) that many military personnel face. How to research such longitudinal situations will be a major focus of the workshop.

Active Versus Passive Learning

Retention of knowledge and skill is better when material at the time of acquisition is processed deeply, embellished, and connected to and integrated with other knowledge – in general, when knowledge is not compartmentalized, but is richly structured and indexed. Material to be learned is actively manipulated, rather than being merely repeated in learning. Manipulations supporting active learning may include extrapolating, discussing, Concept Mapping, alternative perspective

taking, practicing on related problems and cases, creating related projects, and so forth (Bransford, Brown and Cocking, 2000; see also Canas, et al., 2003).

Tapping the Deep Structure and Developing Rich Understanding
Retention of knowledge and skill is better when complex material is "understood," rather than learned by rote; when concepts principles, and rules complement or supplement teaching of rote knowledge or facts. Novices approach complex problems much differently from experts. Novices code problems in term of their surface features (e.g., the objects involved) and try to link (meager) solutions to these interpretations, which in most complex fields cannot support rich problem solving. Experts, in turn, understand problems, by encoding their "deep" structure, often functional, integrated relationships that can be functionally tied to solutions (Chi, Feltovich and Glaser, 1981). These deep structures are abstract, and hence support both transfer and retention (Zeitz, 1997).

Redundant Indexing, Multiple Representations
A fact of our modern world is change and diversity. People are expected to have multiple jobs over a career, jobs themselves change, customization is required, work tools change, technology encroaches, and so forth. Knowledge and skills that will need to be used in many ways must be practiced in many ways, construed in many ways, connected and indexed in many ways, and represented in many ways (e.g., Spiro, et al., 1992, Spiro, Thota, Collins and Feltovich, 2004). This affects retention by supporting redundant indexing, cross-case connectivity, and cognitive flexibility in dealing with novel instances over time. (Spiro, et al., 1988).

Understanding Concepts in Context and Making Fine Discriminations
Experts develop vast memory, organized for finely tuned cases and case-elements within their field of mastery (Ericsson et. al., 2006). This helps them finely discriminate case elements as indexes for just the right structure(s) in memory. Well-tuned case structure memories enable better indexing, anticipation of "what's next," and understanding of when an initially triggered model for interpretation is ill-suited (i.e., has gone down the wrong path) (Feltovich, Spiro, & Coulson, 1997). This affects retention in that it is important that the *right* information is recalled flexibly over time.

Cognitive Transformation and Undoing Bad Learning
Unfortunately, it has been found that in areas of learning that are difficult, learners can develop highly engrained, overly simplistic misconceptions that can impede greater understanding over time. This affects retention in that, even with long-term practice, it is *wrong* understandings that are being reinforced, maintained. Methods of instruction based on Cognitive Transformation Theory (Klein and Baxter, 2009), and Cognitive Flexibility Theory (Spiro, et al., 1988) are aimed at undermining faulty conceptions (as well as supporting the development of better ones).

Practice and Continuous Learning
Clearly, the best means for retaining knowledge and skills is to never stop practicing and learning. This is the bedrock of expertise research, reflected in the concept of life-long "deliberate practice" (Ericsson et al., 2006). It has even been shown that, for experts, knowledge and skills directly from their field of expertise are the last to degrade with the advent of age-related dementia, perhaps the ultimate retention (e.g., Krampe and Charness, 2006).

Transfer-Appropriate Processing
Retention is more effective when conditions of training and learning resemble those in which the learned knowledge and skill will be applied. This condition for retention and transfer is complicated in ill-structured domains, where there can be special demands for knowledge transfer that result from the likely variability between conditions of initial learning and later use. This accentuates the need for training that uses multiple cases, multiple perspectives, and multiple goals for knowledge use in the course of learning.

Focal Points for the Working Meeting

The following core topics will be addressed.

Measures and Levels of Proficiency
This topic addresses the measurement methodology to determine levels of proficiency. This needs to go beyond the traditional rough cuts often used in organizations and expertise studies (i.e., expert versus novice) to achieve finer discriminations along the skill continuum (e.g., Hoffman, 1998). The challenge is to establish reliable and valid markers that might be used for such things as placement, promotions, and for use in assigning practitioners to skill levels in research studies. In this regard, measurement of performance for all complex sociotechnical systems must also go well beyond traditional measures of the performance of individuals (hits, errors, rate, etc.) (Alberts and Hayes, 2003).

Selection and Scaffolding for Development
Traditional hiring practices have not served well to predict who will eventually be a high performer. New methods need to be investigated. For instance, it may be that common screening tools at hiring will need to be replaced or augmented by various indicators that only become apparent after some period of time functioning on the job. Along with identification, there will need to be programs for supporting progressive development beyond what are typically taken to be "professional development" activities in many organizations.

Mentoring and Apprenticeship
Many aspects of work are best learned "at the bench," under guidance from a skilled mentor. These include what is often called "tacit knowledge," that is, many aspects of "know how," where opportunities for learning largely manifest themselves in the course of real, active work, in the social context of work (Schön, 1983). We need to be able to identify excellent mentors, study them to reveal the knowledge and strategies of mentors, and develop programs for training mentors. We also need to determine what job practices are best suited for mentoring, as opposed to using other kinds of training techniques.

Practice and Experience Compression
It is well known that extensive experience with challenging cases and deliberate practice (and guidance) are hallmarks of the development of expertise. One likely reason for the "10,000 hours" guideline for the development of expertise is that ordinary work flow does not provide enough exposure to "tough cases," those that stretch skill, and does not present them within any

kind of logical structure for learning. Finding ways to compact experiences will be vital to any program aiming to accelerate expertise. Methods might include games, simulations, virtual worlds, decision-making exercises, and other kinds of case-oriented delivery systems (e.g., Spiro, Thota, and Feltovich, 2003).

Scaling Cases

Experience with cases is critical to the development of expertise, as is compression of these experiences. Research to reliably test degree of learning, retention, and adaptation, will need a set of dependable scenarios or cases that can be scaled for difficulty, and that span a range of situations. Well-known knowledge elicitation methods (e.g., the Critical Decision Method; Crandall, Klein and Hoffman, 2006) can be employed, with participants who span the proficiency scale (i.e., novice, apprentice, journeyman, expert) to elicit cases. Hence, it will be necessary to develop a large case repository in which cases are scaled for difficulty relative to the different levels of proficiency. For each level we will need cases that are fairly ordinary at that level, but also "level stretchers"— tough cases that push capability beyond the current rank. Such a case library can be used in training, evaluation, and research projects.

Designing Case Libraries

Case experience is so important to expertise that it can be envisioned that organizations will develop very large case repositories for use in training, but also to preserve organizational memory. Instruction using cases is greatly enhanced when "just the right case" or set of cases can be engaged at a prime learning moment for a learner (Kolodner, 1993). (This also argues for large numbers of cases, to cover many contingencies) This is a matter of organization among cases, good retrieval schemes, and smart indexing. Note that an added benefit from the creation of case repositories is that the process of developing cases is itself a form of knowledge elicitation, and therefore it feeds directly into the process of capturing expert knowledge.

Learning for Flexibility, Adaptability, and Resilience

Robustness is the ability to maintain effectiveness across a range of tasks, situations, and conditions. Resilience is the ability to recover from a destabilizing perturbation in the work as it attempts to reach its primary goals. Adaptivity is the ability to employ multiple ways to succeed and the capacity to move seamlessly among them. Fundamental to the achievement of robustness, resilience and adaptivity is the opportunity to practice at problems that stretch current competency (Ericsson and Lehmann, 1996; Feltovich, et al., 1997). However, modern work presents challenges for achieving such adaptive skills. For much of history, individuals have developed mastery and resilience by focusing intensely on a relatively circumscribed task or suite of skills, e.g., chess or welding. Modern work (especially in sociotechnical work systems) has become much more unstable and complex. People change jobs, jobs change, orders change, technology intrudes and changes the work, customization in products and services requires versatility beyond the assembly line, etc. Can we train (or select for) expertise in flexibility and resourcefulness? What kind(s) of learning and materials does it require? For example, one method that has been used is to have workers rotate through other job roles that are integrated with their own work.

Addressing All of These Factors, and More, in the Context of Teams and Groups

In addition to fluidity, customization, etc., another prominent feature of modern work involves teams and teamwork. For functional, workable acceleration to be possible, training exercises must encourage the acquisition of teamwork skills. An expert group is not the same as a group of experts (Salas, et al., 2006). While many skills may be in common, teamwork engages others, for example, certain kinds of "people skills," coordination skills, understanding of others and their "ways," and the ability to develop and maintain satisfactory mutual understanding, "common ground" (Klein, Feltovich, Bradshaw, and Woods, 2004).

Reacquisition of Competency
As discussed above, military personnel face challenges of not only retaining competency, but also reacquiring competency once it has been degraded through non-use after long hiatuses. This phenomenon caused by perhaps years away from domains of primary competency is relatively unique to the military and has not really been studied by learning researchers. Therefore, we are left to largely wonder if principles of reacquisition that have been studied in shorter hiatuses might be applicable to the situation faced in the military, or will empirical study reveal new principles.

Specific Meeting Activities

The Working Meeting will have a focus on identifying important and difficult areas of Air Force and civilian work-practice for which it is feasible to conduct actual programs of research to accelerate and retain expertise, and to reacquire expertise once degraded or lost completely.

The Working Meeting will have a goal of generating detailed roadmaps for how one or more such research projects would be planned and conducted, including the resources and capabilities required.

Identify candidate sub-domains for analysis and focus: We will begin to identify domains that might be a focus for attempts to accelerate the achievement of expertise. We will seek mission critical areas that manifest some combination of these features:

- Hard to learn and do well, as attested to, for instance, by high wash-out rates and few extant experts;
- Have in the past required very long training and on-the-job experience;
- Demonstrate complexity in that they involve many interacting components and stakeholders; are dynamic;
- Are irregular in that different versions of the "same problem" may look very different; and Reflect complex, dynamic and nonlinear patterns of causation, and decision making under uncertainty.
- Have potential for significant cross-over applications of accelerated learning to the civilian sector and are also possible candidate domains for analysis, such as weather forecasting.

The road-mapping effort will converge on the identification of at least two (and ideally three) domains that are interestingly as well as substantively different, that are mission critical, and that depend on expertise and high levels of proficiency (see the discussion above on the

identification of candidate sub-domains. While one might seek to design and conduct a single study on acceleration, in some single selected domain, that would serve only as a demonstration and would not capitalize on the potential of the proposed working meeting. Thus, the anticipated product would include more than one roadmap for acceleration projects in more than one domain, to allow scientific comparisons and convergence.

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