ARI Research Note 2007-02

The Army Science of Learning Workshop

Kathleen A. Quinkert
U.S. Army Research Institute

John E. Morrison, J. D. Fletcher, Franklin L. Moses, and Eric J. Roberts
Institute for Defense Analyses

TRADOC Scientific Coordination Office
Kathleen A. Quinkert, Chief

January 2007

United States Army Research Institute
for the Behavioral and Social Sciences

U.S. Army Research Institute for the Behavioral and Social Sciences

A Directorate of the Department of the Army Deputy Chief of Staff, G1

Authorized and approved for distribution:

SCOTT E. GRAHAM
Acting Technical Director

MICHELLE SAMS
Acting Director

Technical review by

Diana Tierney, U.S. Army Training and Doctrine Command
Jean L. Dyer, U.S. Army Research Institute

NOTICES

DISTRIBUTION: This Research Note has been cleared for release to the Defense Technical Information Center (DTIC) to comply with regulatory requirements. It has been given no primary distribution other than to DTIC and will be available only through DTIC or the National Technical Information Service (NTIS).

FINAL DISPOSITION: This Research Note may be destroyed when it is no longer needed. Please do not return it to the U.S. Army Research Institute for the Behavioral and Social Sciences.

NOTE: The views, opinions, and findings in this Research Note are those of the author(s) and should not be construed as an official Department of the Army position, policy, or decision unless so designated by other authorized documents.

REPORT DOCUMENTATION PAGE

1. REPORT DATE (dd-mm-yy)	2. REPORT TYPE	3. DATES COVERED (from. . . to)
January 2007	Final	May 2006 - January 2007

4. TITLE AND SUBTITLE	5a. CONTRACT OR GRANT NUMBER
The Army Science of Learning Workshop	DASW01-04-C-0003 and W74V8H-05-C-0042
	5b. PROGRAM ELEMENT NUMBER 2O263007

6. AUTHOR(S)	5c. PROJECT NUMBER
Kathleen A. Quinkert (U.S. Army Research Institute) John E. Morrison, J. Dexter Fletcher, Franklin L. Moses, and Eric J. Roberts (Institute for Defense Analyses)	A792
	5d. TASK NUMBER 349
	5e. WORK UNIT NUMBER

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)	8. PERFORMING ORGANIZATION REPORT NUMBER
U.S. Army Research Institute for the Behavioral and Social Sciences ATTN: DAPE-ARI-ZM 2511 Jefferson Davis Highway Arlington, VA 22202-3926	

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)	10. MONITOR ACRONYM
U.S. Army Research Institute for the Behavioral and Social Sciences 2511 Jefferson Davis Highway Arlington, VA 22202-3926	ARI
	11. MONITOR REPORT NUMBER Research Note 2007-02

12. DISTRIBUTION/AVAILABILITY STATEMENT

Approved for public release; distribution is unlimited.

13. SUPPLEMENTARY NOTES

Contracting Officer's Representative and Subject Matter POC: Kathleen A. Quinkert

14. ABSTRACT *(Maximum 200 words)*:

At the request of TRADOC, ARI brought together key stakeholders in Army training and education together with experts from academia, industry, and other Military Services for a 3-day workshop. The purpose of this workshop was to identify learning science findings and technologies to help the Army train Soldiers and grow leaders for today and tomorrow. Ninety-five individual workshop participants were divided into four working groups that discussed four distinct problems in training. The following are some of the more notable findings and recommendations from those four working groups: (a) Learning Model—try out an instructional development and execution strategy that is grounded in the science of learning; (b) Develop Leaders—integrate social networks, communities of practice, and Army Knowledge Online (AKO) as an electronic supplement to socialization and relationship building; (c) Train Soldiers—use distance learning (dL) to accelerate training, reduce costs and personnel requirements and to improve operational effectiveness without adversely affecting Soldiers or their families; and (d) Future Capabilities—maintain a robust agenda of multidisciplinary research to include (but not be limited to) the following general topic areas: learning and performance, social and cultural behavior, human-machine performance, predictive models of readiness and performance, and collective performance modeling.

15. SUBJECT TERMS

Army Training, Instructional Design and Development, Learning Model, Science of Learning, Training Model

SECURITY CLASSIFICATION OF			19. LIMITATION OF ABSTRACT	20. NUMBER OF PAGES	21. RESPONSIBLE PERSON
16. REPORT	17. ABSTRACT	18. THIS PAGE			
Unclassified	Unclassified	Unclassified	Unlimited	62	Ellen Kinzer Technical Publication Specialist (703) 602-8047

Research Note 2007-02

The Army Science of Learning Workshop

Kathleen A. Quinkert
U.S. Army Research Institute

John E. Morrison, J. D. Fletcher, Franklin L. Moses, and Eric J. Roberts
Institute for Defense Analyses

TRADOC Scientific Coordination Office
Kathleen A. Quinkert, Chief

U.S. Army Research Institute for the Behavioral and Social Sciences
2511 Jefferson Davis Highway, Arlington, Virginia 22202-3926

January 2007

Army Project Number
633007A792

Personnel Performance and Training

ACKNOWLEDGEMENTS

Many people contributed to the success of the Science of Learning Workshop. The authors gratefully acknowledge the contributions and assistance of individuals who were particularly instrumental in this effort. The working group facilitators were especially involved in this project by defining the questions addressed in the groups, guiding the discussion, and summarizing the results for Army leadership. Senior researchers from the Army Research Institute served in this key role: Mr. Ron Stump, Dr. Scott Graham, Dr. Stanley Halpin, and Dr. Steven Goldberg.

Input from Senior Army leadership was provided through the Executive Committee, which helped define the overall concept for the workshop and provided valuable advice and feedback during the effort. This committee was chaired by General William S. Wallace, the Commander of the U.S. Army Training and Doctrine Command (TRADOC), and included Lieutenant General Paul Funk, U.S. Army (Ret.); Lieutenant General Larry Jordan, U.S. Army (Ret.); Mr. Robert Seger, TRADOC Deputy Chief of Staff for Operations and Training; Mr. James Gunlicks, Deputy Director of Training, Army G3; Dr. Michelle Sams, Acting Director of the Army Research Institute; and Lieutenant Colonel Kevin McRee, TRADOC Commanding General's Planning Group.

The success of the workshop was also due, in no small part, to the support staff. Three employees of Science Applications International Corporation worked tirelessly to plan workshop events and ensured that the events were executed as planned: Ms. Paula Poole, Ms. Debra Anderson, and Ms. Norma Zaske.

THE ARMY SCIENCE OF LEARNING WORKSHOP

EXECUTIVE SUMMARY

Research Requirement:

The U.S. Army Training and Doctrine Command (TRADOC) is redefining its role to be the "Architect of the Army" to better support and shape the Operational Force. In that role, TRADOC is looking outside the organization to understand better the fundamental learning processes and state-of-the-art training technologies. To facilitate that process, the U.S. Army Research Institute for the Behavioral and Social Sciences (ARI) sponsored a workshop that brought together key stakeholders in Army training and education experts from academia and industry, and representatives of other Services. The overall purpose of this workshop was to identify learning science findings and technologies that will help the Army train Soldiers and grow leaders for today and tomorrow.

Procedure:

Ninety-five individuals participated in the 3-day workshop, which was conducted from 1–3 August 2006 in Hampton, Virginia. The participants were divided into four working groups that discussed fundamental but distinct problems in training: (1) *Learning Model:* discuss whether the Army should define a force-wide "learning model" to guide training development, execution, and feedback; (2) *Train Soldiers:* discuss new pedagogical techniques, procedures, and technologies that can be adopted to reshape the Army's training and education system; (3) *Develop Leaders:* identify and discuss possible strategies for accelerating the growth of key leader skills, which are thought to support adaptability skills; and (4) *Future Capabilities:* envision how advances in learning science and training technology can be used to train Soldiers and grow leaders more effectively.

Some participants provided white papers on selected topics within these problem areas, and the products were posted to a Web site before the workshop.

Findings:

The following list provides some of the more notable findings from the four working groups:

1. Learning Model
    a. As a proof of principle, the Army should implement the Guided Experiential Learning (GEL) model on a limited basis as an example of a scientifically based instructional design, development, and execution strategy.
    b. Human Performance Improvement (HPI) is an analytic method that views training as one of many approaches for solving human performance problems. The HPI should be studied to determine how it could be used to address Army problems and what implications that would have for the Force and its organizations.

c. Early face-to-face (f2f) interaction can have significant learning benefits in terms of enhancing learning, increasing satisfaction, and decreasing attrition in a blended (i.e., live/virtual) training environment.

2. Train Soldiers
   a. Implement distance learning (dL) to accelerate training, reduce costs and personnel requirements, enhance human performance, and improve operational effectiveness. Initial investment resources must be identified and applied to ensure dL quality, overcome cultural and administrative inertia, provide adequate training for developers and instructors, and develop the training capabilities that are uniquely available through the use of dL technologies.
   b. Streamline Army training by developing explicit, cooperative agreements between Army training and personnel communities to ensure assignment of credit and early application of newly developed personnel competencies, provide assignments and certifications that adequately accommodate anytime, anywhere dL course completions, and use dL to focus training on individuals' current and pending duty assignments. Establish standing processes to harmonize and balance the training objectives sought by TRADOC and the United States Army Forces Command (FORSCOM) and to integrate the use of performance/decision aids with programs of instruction.
   c. Train all stakeholders, including students, instructors, developers, and training managers, in the use of dL to ensure its use and to realize the benefits it offers for improving operational effectiveness through more effective and efficient Army training.

3. Develop Leaders
   a. Integrate social networks, communities of practice, and Army Knowledge Online (AKO) as an electronic supplement to socialization and relationship building.
   b. Leverage key intervention points in the Army's education system to influence leaders' ability to effect change in their units through socialization and add adaptability to Doctrine (Headquarters, Department of the Army, 2002) and to personnel system requirements.
   c. Review available training practices for opportunities to enhance adaptability using what we know and what works as guidelines.

4. Future Capabilities

Maintain a robust agenda of multidisciplinary research to include (but not be limited to) the following general topic areas:
   a. learning and performance,
   b. social and cultural behavior,
   c. human-machine performance,
   d. predictive models of readiness and performance, and
   e. collective performance modeling.

Utilization and Dissemination of Findings:

Initial findings were briefed to the TRADOC Commander and the workshop Executive Panel on the third day of the workshop. The Commander used the initial briefing to make

recommendations to the Deputy Assistant Secretary for Research and Technology, who was a member of the Executive Panel, for future research and development (R&D). More detailed findings and recommendations will be delivered with this report, and a final report will synthesize the diverse recommendations into a comprehensive model of Army learning.

THE ARMY SCIENCE OF LEARNING WORKSHOP

CONTENTS

APPENDIXES[1]

List of Tables

[1] Appendixes are provided on a separate Compact Disk (CD) located in the sleeve of the back cover of this report.

Page

List of Figures

THE ARMY SCIENCE OF LEARNING WORKSHOP

I. INTRODUCTION AND BACKGROUND

This report provides an account of the Army Science of Learning Workshop, which conducted on 1–3 August 2006 in Hampton, Virginia. The workshop brought together key stakeholders in Army training and education, experts from academia and industry, and representatives of other Services.

The overall purpose of the workshop was to identify learning science findings and technologies to help the Army train Soldiers and grow leaders for today and tomorrow. From this overall statement of purpose, the following major goals and objectives were derived:

- Accelerate learning while maintaining effectiveness by
  - incorporating principles and methods from the science of learning
  - leveraging learning technologies
  - rapidly inserting lessons learned into training and leader development.

- Minimize resource requirements (time, cost, people) by
  - streamlining time in institutional training and education
  - accelerating leader development
  - choosing technology-based solutions based on learning effectiveness.

- Minimize impacts on
  - relationships (personal, professional, unit cohesion)
  - quality of life.

This section of the report provides background on workshop issues by summarizing the addresses of the keynote speakers. It concludes with specific questions posed by Commanding General, U. S. Army Training and Doctrine Command (TRADOC), General William S. Wallace. As described in Section II, the workshop was divided into four working groups (Learning Model, Train Soldiers, Develop Leaders, and Future Capabilities) to answer General Wallace's questions. Sections III–VI document the results from each of the working groups. The last section (Section VII) provides some implications for short- and mid-term actions. The workshop products are documented in the appendixes, which are provided on a compact disk (CD) placed in a sleeve on the back page of the report. Appendix A contains a list of acronyms and abbreviations.

Keeping TRADOC in Balance

In an article for *Military Review*, General William S. Wallace (2006) asserted that TRADOC is in the midst of a fundamental transformation. In the past, TRADOC was viewed as a cornerstone of the Institutional Army because it provided trained personnel and doctrine for the Operational Army to execute its missions. TRADOC support, in its traditional role, flowed in one direction: from the Institutional to the Operational Army, without the benefit of feedback in

the reverse direction (Figure 1 PAST). However, given the unpredictability of combat conditions and the rapid adaptability of threats, this linear model is no longer appropriate. The evolving model is to view TRADOC as the Generating Force that is fully integrated with the Operating Force (Figure 1 FUTURE). The integration of Generating and Operating Forces allow lessons learned and other feedback to be applied to improve training and doctrine rapidly within and between the two force components. Although the lines between Generating and Operating Forces have been blurred, TRADOC still provides intellectual guidance to learn from operational experience and anticipate future solutions to tomorrow's challenges. In this role, TRADOC serves as the "Architect of the Army" in supporting and shaping the Operating Force.

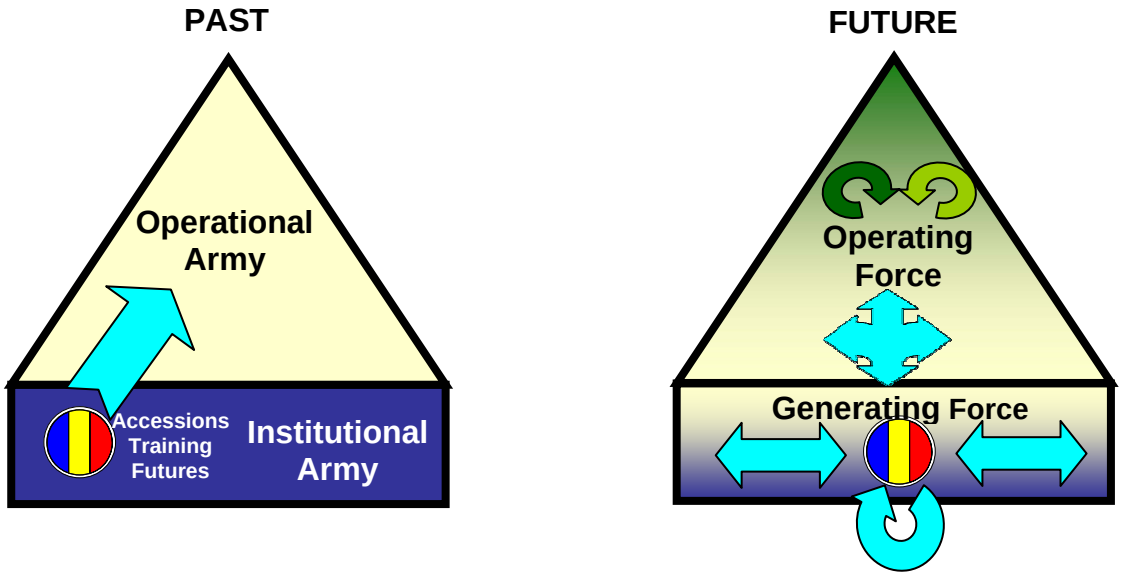

Figure 1. Relationship of TRADOC to the Army.

General Wallace (2007), in his keynote address to this workshop, portrayed TRADOC in a pivotal role, seeking to balance the increasing demands of modern warfare with emerging technical and organizational capabilities. As indicated by the red squares as the bottom right of Figure 2, TRADOC is experiencing greater demand to produce trained Soldiers, develop leaders, and support training through Mobile Training Teams (MTTs). Exacerbating the situation is the fact that TRADOC must cope with these increasing output requirements while facing significant budgetary and personnel reductions (Figure 2 top left).

Helping to mitigate these negative forces are three organizational changes designed to improve Army processes through (a) innovations in the requirements process to make it more responsive to Soldier current and future needs, (b) increases in authority provided by the Force Generation concept, and (c) alignments of modular forces with campaign needs. In addition to these three emerging capabilities, a fourth pertains to the ability to train individuals and units to adapt to rapidly developing and unforeseen changes to the threat and the battlespace. This workshop focuses on this latter capability by examining the possible contributions of the science of learning to military training and education.

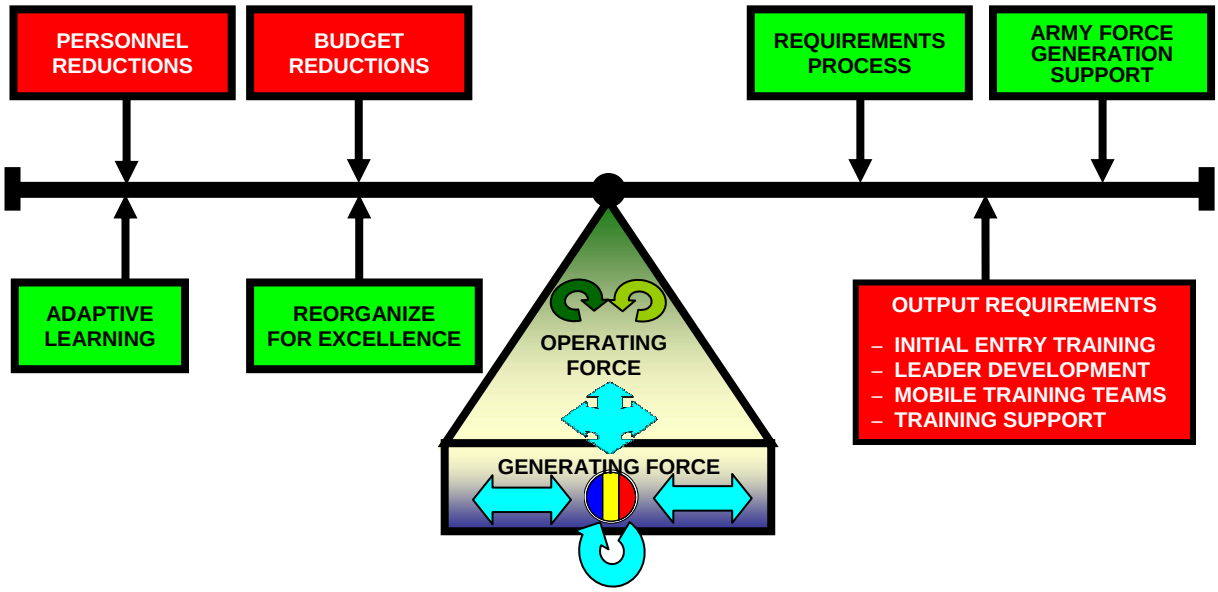

Figure 2. TRADOC as the pivot between constraints and capabilities.

The Science of Learning

Dr. Michelle Sams (2007), in her welcome address to participants of the workshop, echoed the theme that the Army is "…undergoing major personnel, organizational, and training transformation to ensure a ready and relevant force." To ensure that the Army continues to develop effective, efficient training and leader development programs, she maintained that TRADOC must be well grounded in the learning sciences. Her talk reviewed three big science of learning paradigms that have dominated psychology since the 1930s: behaviorism, cognitivism, and constructivism. She also described two new paradigms, which may dominate future theory and research: cognitive neuroscience and holistic humanistic psychology. Whether these new approaches produce antithetical paradigms or ultimately merge into a multidisciplinary science is yet to be seen. Currently, the science of learning is not an integrated field with unambiguous prescriptions for education, training, and development; rather, Dr. Sams characterized it as more like a complex jigsaw puzzle with some parts completed but many pieces still missing. She concluded that one of the purposes of the workshop was to help fill in the puzzle for TRADOC by interpreting the incomplete picture and predicting the placement of the new parts.

Professor Robert A. Bjork (2007), in his keynote address to the workshop, also indicated that the science of learning is as old as the science of psychology; however, significant advances have been realized in the last 40 years. Bjork pointed out that these advances have revealed that our intuitions about learning are often incorrect and lead to misleading conclusions about skill acquisition, transfer, and retention. One of the more common misunderstandings is that learning is often equated with performance. Research indicates that conditions that make performance improve rapidly often do not promote long-term retention and transfer. Conversely, conditions that slow learning enhance long-term retention and transfer. However, simply making learning more difficult does not ensure long-term retention. Some difficulties would impede learning and retention. Instead, trainers should introduce "desirable difficulties" that, while slowing learning,

improve long-term retention and transfer—processes that are considered requirements for adaptable performance. Bjork (1994) identified the following manipulations that have been identified as slowing learning but enhancing long-term retention and transfer:

- varying the conditions of learning,
- providing "contextual interference" during learning (e.g., interleaving rather than blocking practice),
- distributing or spacing study or practice sessions,
- reducing feedback to the learner, and
- using tests (rather than presentations) as learning events.

Major General (Retired) Robert H. Scales (2006) agreed that the science of learning is key to understanding basic learning and training phenomena. Moreover, he portrayed learning and other human-related sciences as playing an even larger role in future warfare. Professor Alan Beyerchen of Ohio State University has used the term "amplifier" to describe key conceptual factors that have nonlinear effects on warfare outcomes but that differentiate types of warfare. For instance, the amplifier for World War I was chemistry (e.g., poison gas and synthetic explosives), whereas the amplifier for World War II was physics (e.g., radar and atomic weapons). Scales argued that the principal factor in World War III, or the Cold War, was information technology (e.g., intelligence and knowledge of the enemy), which was used to defeat the Soviet threat with remarkably little loss of life. However, we now find ourselves in a new era (World War IV), where the centers of gravity are no longer the will of governments and armies but are the perceptions of populations. In this new and evolving stage of warfare, the amplifier will shift from physical technology to the biological and social sciences. Scales identified the following nine areas where the science of learning (and other human-related sciences) will be used to provide specific military capabilities:

1. increasing cultural awareness,
2. building alien armies and alliances,
3. shaping opinions among alien individuals and cultures,
4. encouraging reflective and informed reasoning,
5. exploiting tactical intelligence,
6. preparing warfighters for physical and psychological stresses of combat,
7. training high-performing teams and individuals,
8. enhancing leadership and decision-making skills, and
9. developing intuitive battle command procedures.

The Navy's Model of Learning

The science of learning has been successfully used as the foundation for training models and methods in industry and government. Of particular interest and relevance is the integrated approach to military training and education as described in the Executive Review of Navy

Training (ERNT) (Executive Review of Navy Training, 2001). The Navy's model is built on the notion of human competencies—that is, knowledge, skills, abilities, and tools (KSATs) that Sailors bring to the job and/or KSATs required by a particular Navy rating (job). Vice Admiral J. Kevin Moran (2007), in his keynote address to the workshop, reported that KSATs have been identified for every enlisted rating in the U.S. Navy. The KSATs have been entered into a database and are organized around five vectors that describe different aspects of job success: (1) professional development, (2) personal development, (3) professional military education and leadership, (4) certifications and qualifications, and (5) performance. As shown in Figure 3, the vectors are also ordered into four performance levels: (1) recruit, (2) apprentice, (3) journeyman, and (4) master. This Five-Vector Model (5VM) is used to describe progress through the continuum of training and education, both in terms of individual Sailor backgrounds (i.e., an electronic résumé) and requirements for successful job performance.

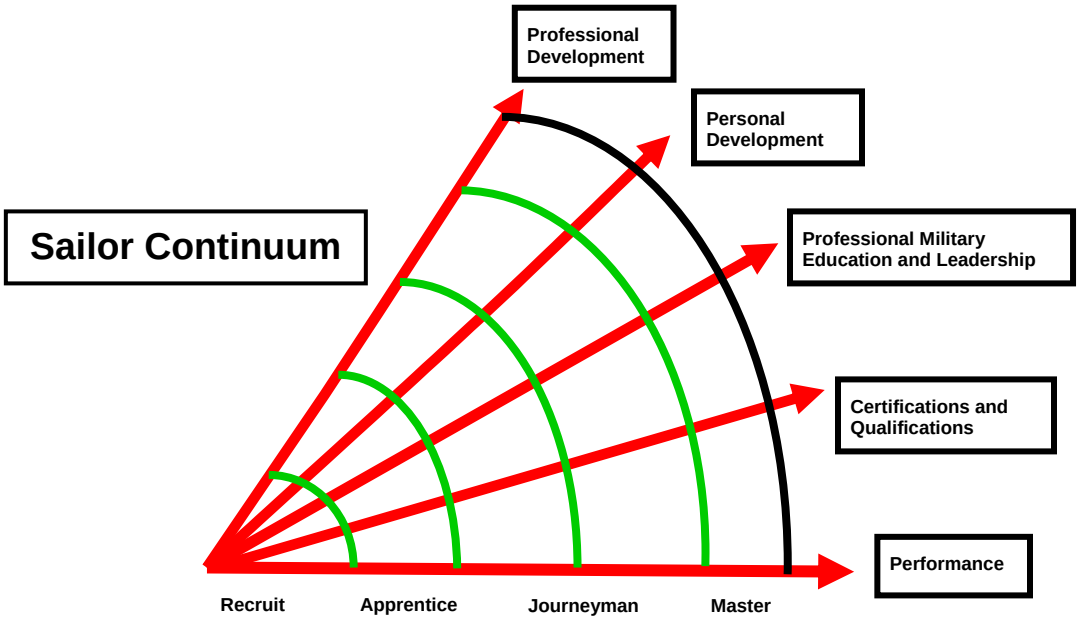

Figure 3. Pictorial representation of the Navy's 5VM.

An automated system called the Integrated Learning Environment (ILE) uses the KSAT database to perform a gap analysis between requirements for future jobs and a Sailor's current status. The results of the gap analysis provide prescriptions for acquiring needed elements. As depicted in Figure 4, the prescriptions for learning include the full gamut of possible methods. [This particular model of Navy learning was adapted from International Business Machines Corporation (IBM) (Executive Review of Navy Training, 2001).] Although computer-mediated learning is specified in the upper right quadrant of this model, electronic learning (e-learning) technology can be used to deliver or supplement any of the six training methods in the model. Navy Knowledge Online (NKO) serves as the central portal for all e-earning content and can be accessed by all Sailors. The 5VM model and tools such as the ILE and NKO provide a system for the Sailor to take charge of his/her own career and professional development.

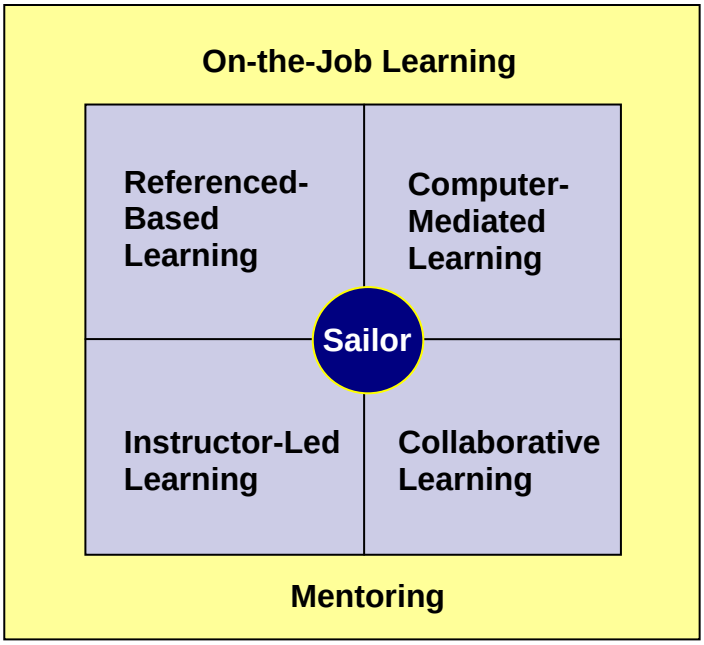

Figure 4. Navy model of learning and training delivery approaches.

Workshop Expectations

Given this general background, General Wallace (2007) articulated his expectations for this workshop:

- Gain a better appreciation for how we learn
- Understand and how young people (future Soldiers) learn
- Bring forward practical ideas and approaches for Army consideration
  - Realistic
  - Resource constrained
  - Best practices – known methods
- Identify gaps in knowledge for future research and/or development.

II. WORKSHOP APPROACH

Participants

A total of 95 individuals participated in the workshop. They were selected based on their individual fields of expertise. Although most of the participants were directly associated with the Army, a concerted effort was made to include individuals who did not have direct ties to the Army. As shown in Table 1, these non-Army individuals were drawn from other military Services (Navy and Coast Guard), civilian government agencies, industry, and academia. Appendix B provides a complete list of participants and their organizations.

Table 1
Distribution of Individuals Participating in the Army Science of Learning Workshop

Organization	No. of Participants
Army	
Active Military	21
Retired	4
U.S. Army Research Institute for the Behavioral and Social Sciences (ARI)	15
Civilian (non-ARI)	19
Subtotal	59
Other Military Services/Government Agencies	
Military	5
Civilian	7
Institute for Defense Analyses (IDA)	4
Subtotal	16
Industry	8
Academia	12
Total	95

Workshop Organization

Before the workshop, planners nominated and invited participants and assigned them to working groups. Appendix B shows their individual assignments. The following describes these groups and their functions.

Working Groups

The workshop participants were assigned to one of four working groups (Learning Model, Train Soldiers, Develop Leaders, and Future Capabilities) based on their expertise. Each working group was chaired by a facilitator, who was a senior ARI researcher, and assisted by a stakeholder, who represented TRADOC interests. The working group chair nominated participants for their respective groups and developed the objectives for their activities, which are described as follows:

- *Learning Model.* This group examined learning models of other Services and organizations to extract best practices and lessons learned that could be applicable for an Army learning model.

- *Train Soldiers.* This group examined the reshaping of the Army's training and education system. It focused on how advances in the science of learning have provided new pedagogical techniques, procedures, and technologies that can be used to offset pending schoolhouse resource reductions.

- *Develop Leaders.* This group examined what we know about "adaptability" and explored possible strategies for accelerating the growth of key leader skills that are thought to support adaptability. It also discussed some of the organizational factors (socialization, cohesion) that help to establish the climate within which adaptable leaders perform.

- *Future Capabilities.* This group's goal was to envision what learning science and emerging technologies will offer within the next decade and articulate how the Army might take advantage of these technologies to train Soldiers and grow leaders more effectively.

Executive Panel

A small group of senior participants (retired general officers and senior civil servants) served on the Executive Panel. These individuals observed all the working groups and provided their expertise as needed. The panel also advised General Wallace on how to implement the recommendations of the working groups.

Workshop Activities

The workshop was conducted over 3 days (1–3 August 2006) at the Hampton Radisson Hotel near Fort Monroe, Virginia. Appendix C provides a detailed agenda of workshop activities.

On the morning of Day 1, the participants met in a plenary session for a series of keynote addresses. Appendix D contains keynote address slides and notes. After lunch, participants joined their working groups. Participants continued to work in those same groups through Day 2. The morning of Day 3 was primarily devoted to preparing the working groups outbriefs, which were presented that afternoon.

Workshop Products

Participants created three types of products. Some participants were commissioned to create white papers that were prepared before the workshop and posted on the workshop Web site (http://isupport.geo-centers.com/slw) (see also Appendix E). Briefs based on the white papers were prepared and presented during the working group deliberations (see Appendix F). Finally, the working groups collectively produced briefing slides that their facilitators presented at the outbrief on Day 3 (see Appendix G).

III. LEARNING MODEL WORKING GROUP

This group examined learning models of other large-scale institutions (e.g., the Navy, universities) and corporations to extract best practices and lessons learned that could be applicable for an Army learning model. After discussing the white papers, the group considered the expectations of TRADOC provided by General Wallace and workshop guidance provided by ARI leadership. Many topics were raised and discussed, but, by consensus, the group concentrated on four large issues or questions:

1. How do people learn?

2. What instructional strategies are most effective and efficient?

3. What other opportunities exist to optimize Soldier performance?

4. How can we preserve the learning benefits of cohort socialization in a blended learning environment?

For each of these questions, the group summarized what we know, and, where appropriate, what works, what we don't know, and potential impact (value added) of proposed solutions.

How Do People Learn?

What We Know

Although extant learning theories are numerous, one comprehensive theory of cognition and learning has received an extraordinary degree of acceptance: ACT-R.[2] This model is based on hundreds of empirical experiments and computer models. ACT-R differentiates between two types of knowledge:

- *Declarative knowledge.* This type of knowledge refers to our stored facts about the world. This type of knowledge is consciously mediated, quickly learned, and quite often wrong. Military examples of declarative knowledge include types of tank rounds and the major components of a fire control system.

- *Procedural knowledge.* This type of knowledge underlies our ability to perform skilled and unskilled actions. This type of knowledge is acquired through conscious mediation but becomes unconscious with high levels of practice. Typically, this type of knowledge

[2] Although the use of the acronym "ACT" has been relatively stable, the definition of the acronym has evolved over the years. The original definition was the "Adaptive Character of Thought," which was the title of an influential textbook by Anderson (1990). However, Anderson and Lebiere (1998) published ACT-R 4.0 in a book whose title suggested a new definition of ACT: "Atomic Components of Thought." Others have suggested, perhaps facetiously, that ACT stands for "Anderson's Cognition Theory." The "R" in ACT-R stands for "rational" and refers to the explicit assumption that internal processes are optimized to maximize success while minimizing computational resources. This aspect of cognition, which helps constrain modeling, is assumed to be a result of evolution.

is slowly learned but accurate if appropriate forms of feedback are provided. Examples of procedural knowledge include the actions required to identify and load correct tank rounds and procedures to troubleshoot a malfunctioning fire control system.

What Works

Practical experience with ACT-R indicates that the model provides a sufficient base of evidence for designing appropriate instruction. For instance, being able to specify the declarative and procedural knowledge prerequisites for a course of instruction allows designers to devise appropriate pretests that determine whether students should complete a certain module of instruction.

Implicit in General Wallace's list of expectations was the question whether learning processes differ between generations. In other words, should the Army learning model accommodate differences in basic human capabilities? The ACT-R model is fairly clear in this regard. The fundamental model does not differ in structure or process as a function of age; rather, any age differences are modeled as variations in model parameters or knowledge content. Restated, the ACT-R model implies that generations may differ in what they know or have practiced but no fundamental differences exist in the way they think.

What Instructional Strategies Are Most Effective and Efficient?

What We Know

Years of research and practice have revealed several key attributes that typify effective and efficient training and education. These attributes apply to all types of training and education, independent of specific delivery systems. According to these attributes, effective instruction is

- experiential,
- authentic/current/relevant,
- guided,
- motivational/engaging,
- tailored to the learner, and
- collaborative (sometimes).

What Works

Guided Experiential Learning (GEL) is a method for designing instruction based on principles derived from extensive reviews of the psychological and education research literature (Clark, 2004). GEL is based on a cognitive task analysis (CTA) of the performance domain to determine the required elements of knowledge. Based on this analysis, the GEL model prescribes a generic blueprint for training that specifies the following essential learning activities or components:

- *Clarify objective.* What actions, conditions, and standards will you learn in this course (lesson)?

- *Provide rationale/explain relevance.* What are the benefits to you and your unit when you learn and apply? What are the risks of not learning or applying?

- *Present overview.* How is this course (lesson) structured, and what training strategy is used?

- *Specify declarative knowledge acquisition.* Here are definitions and examples (provided in this lesson) of concepts, processes, and/or principles from a CTA. You need to learn and be able to remember them later.

- *Specify the procedural knowledge demonstration.* In this lesson, observe this CTA-based demonstration because you will be asked to apply it after it is finished.

- *Encourage problem solving and feedback.* Now solve problems or objectives (derived from a CTA) that are similar to those you will encounter in the field. Use the procedure you observed in the demonstration. As you practice, you will receive feedback about the parts of your strategy that are effective and the parts that need to be revised.

What We Don't Know

Although GEL has been proven as an effective method for developing and implementing instruction, some aspects of this method are still not known. The generality of the method and its relation to other instructional techniques have not been fully explored. Also, we do not know the extent to which this method requires a shift in the Army training culture. Another issue relates to the fact that GEL training is tailored to the learner's prior knowledge and skill level. Specifically, what we don't know is how to assess those knowledge and skills effectively and efficiently. To answer these questions, the Army should implement GEL on selected task domains and document its effectiveness and efficiency as an instructional design, development, and execution strategy.

Potential Impact

GEL will probably require more up-front time and effort for CTA and design, but the negative impact will likely be minimized as procedures are codified and standardized across the Army. On the other hand, the potential benefits are great in terms of decreases in time to learn and increases in level of learning. These benefits should be applicable to many different tasks and settings because they are based on scientific (i.e., replicated) evidence.

What Other Opportunities Exist To Optimize Soldier Performance?

Approaches other than training do exist for improving human performance. For instance, improvements can be achieved through personnel selection, doctrine change, and human interface design. Rather than focusing on training per se, industrial and military human resource (HR) experts have argued that analysts should focus on human performance, identify the problem, and then prescribe the appropriate solution. This approach to problem solving is

commonly referred to as the Human Performance Improvement (HPI) model and has been adopted by large industrial and military organizations as the framework within which training and education should be viewed. As an example, Figure 5 summarizes the HPI model used by the Coast Guard and a similar model is used by the Navy. Also, note that the GEL model, as described in the white paper by Professor Richard Clark (2007), incorporates an HPI model as the needs assessment process.

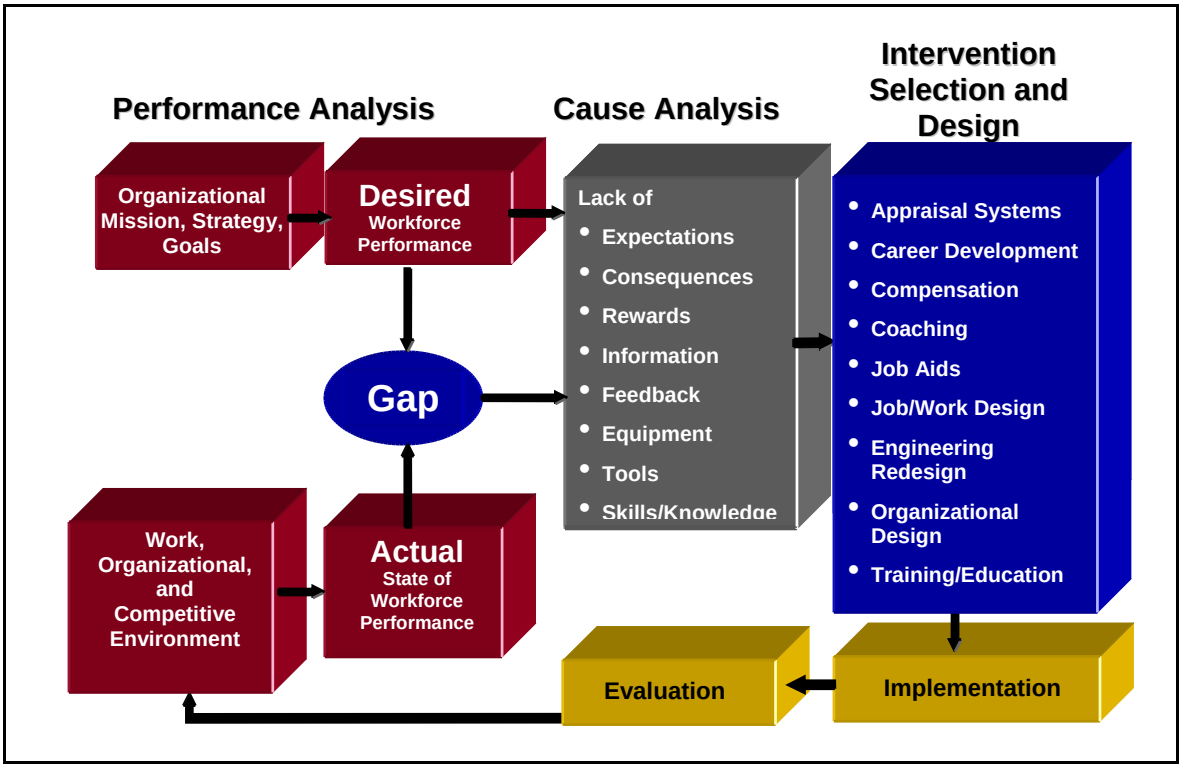

Figure 5. Model of human performance used by the U.S. Coast Guard.

What We Know

Adopting HPI-like models and focusing on performance has enables the U.S. Navy and Coast Guard have realized significant returns on investment (ROIs). The following examples of savings-to-investment ratios illustrate the range of ROIs obtained through HPI analyses:

- 37:1—Navy based on an FY06 summary
- 32:1—Coast Guard example of the Lightweight Satellite Transceiver (LST)-5D
- 10:1 to 100:1—Industry anecdotes based on proprietary data.

Figure 6 summarizes two detailed examples of actual savings in the Navy and Coast Guard. These examples insinuate that ROI estimates are scope dependent, meaning larger ROIs are usually obtained on larger scale projects. Industry ROIs are often difficult to attain because of their dependence on proprietary data; however, the two military examples (Navy, Coast Guard) fall within the range of limited private data (Industry).

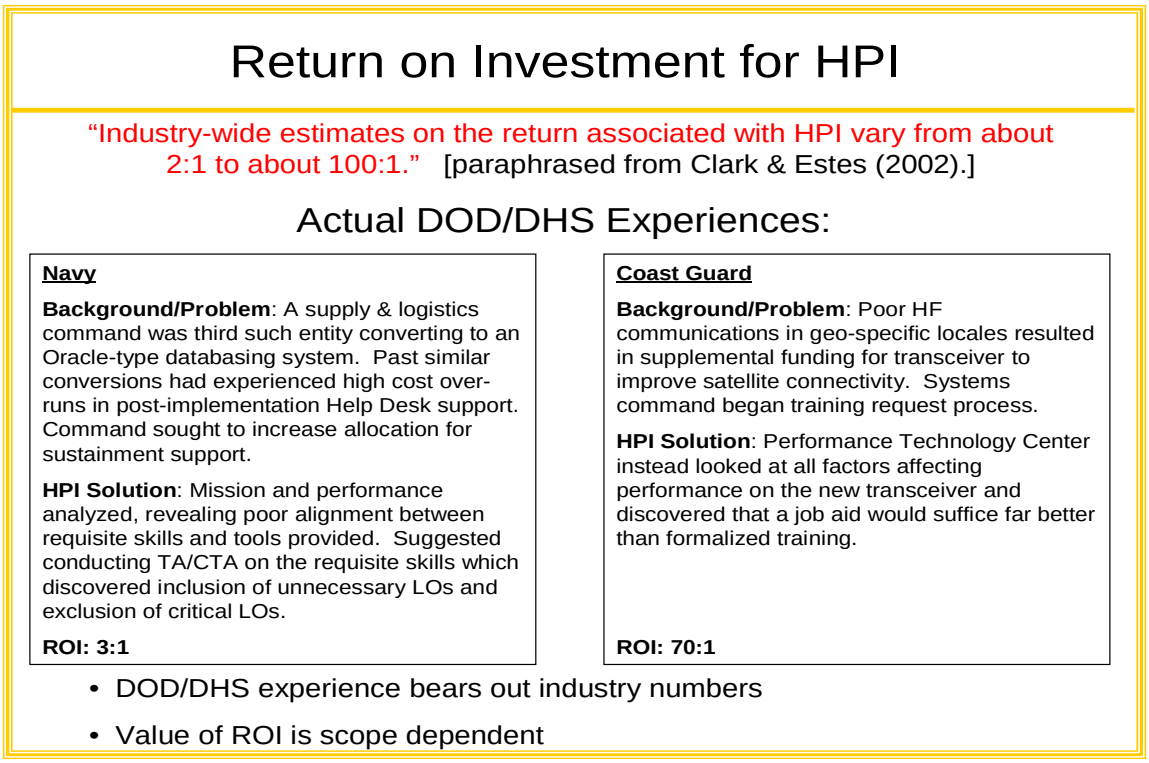

Figure 6. Example ROIs from the Navy and Coast Guard resulting from an implementation of HPI approaches.

What We Don't Know

HPI has been shown to work in large military organizations. However, implementation in the U. S. Army is particularly challenging because no single advocate exists for all facets of human performance. The organizational structure for implementation is not presently known.

Potential Impact

In addition to the ROI listed previously, adopting HPI has several other potential benefits, including

- alignment of HR, training, and acquisition systems;
- elimination of unnecessary training;
- validation and better understanding of the requirements;
- standardization of methodologies;
- adoption of adaptable solutions; and
- attainment of optimal outcomes.

How Can We Preserve the Learning Benefits of Cohort Socialization in a Blended Learning Environment?

The social benefits of traditional Army residential training are that it brings cohorts of peers together in a professional environment, thereby promoting the development of personal relationships and esprit de corps. Also, the social environment promotes collaborative learning strategies, which have been shown to enhance knowledge acquisition and retention. The question is whether the implementation of distance learning (dL) technologies reduces these benefits.

What We Know

For blended environments that mix traditional and dL methods, the empirical evidence suggests early face-to-face (f2f) interaction does have significant learning benefits for enhancing learning, increasing satisfaction, and decreasing attrition. However, the advantages of f2f interaction are decreased if it occurs late in the blended course.

What We Don't Know

Although the benefits of f2f interaction have been established empirically, some aspects remain unknown. Research should address the following:

- f2f interaction is largely based on university research, and the applicability of the findings to the Army environment is unclear.

- Collaborative technologies provide the capability to provide "virtual" f2f interaction at a distance. The relative effectiveness of this form of f2f compared with "live" f2f is unknown.

- The execution details for blended environments are also unknown, including the minimum amount of required f2f time, optimal class size, and appropriate instructor-to-student ratios.

IV. TRAIN SOLDIERS WORKING GROUP

This group examined the reshaping of the Army's training and education system. The group focused on science of learning advances that have provided new pedagogical techniques, procedures, and technologies and how these advances might be used to offset pending schoolhouse resource reductions.

The group was provided with the following list of sample questions, but discussion was not limited to these issues alone:

- How can the Army leverage dL solutions to overcome resource shortfalls?

- How can the Army streamline institutional training courses and align them better with the needs of operational units?
  - What are the effects of Army Force Generation (ARFORGEN) on Army institutional training?

- How should the Army prepare learners, instructors, and training developers to make the best use of new training technologies and approaches?
  - How does the Army fully assess the cost and effectiveness of dL training solutions?
  - What are the appropriate selection criteria for course modules for dL presentation?

For each of these questions, the group summarized what we know, what works, what we don't know, and potential impact (value added) of proposed solutions. Appendix F provides the briefings presented to the group to stimulate and support discussion.

How Can the Army Leverage dL Solutions To Overcome Resource Shortfalls?

What We Know

TRADOC can use dL to reduce training time while maintaining effectiveness. Empirical comparisons of standard classroom learning environments (e.g., text, lecture, and/or laboratory experience) and learning environments using dL capabilities [e.g., Computer-Based Instruction (CBI), Intelligent Tutoring Systems (ITSs), and Interactive Multimedia Instruction (IMI)] have been performed in many different instructional settings across many different subject areas. On average, those that examined time to learn found reductions in training time—time to achieve required instructional objectives—of about 30 percent. These time savings require training that interactively adapts pace, content, and/or sequence to the prior knowledge, needs, and ability of the learner. Such interactive adaptation can also be achieved in the tutoring provided by a single (human) instructor working with a single student, but such an approach is, with few exceptions, unaffordable for large numbers of individual students. Computer-based technologies are needed to support adaptive, affordable dL.

TRADOC can use dL to reduce training costs. Reductions in the time necessary to train can save or avoid training costs by reducing (1) the training resources required to achieve targeted instructional objectives, (2) travel costs, and (3) permanent change of station (PCS) and

temporary duty (TDY) costs. Such reductions could also reduce student pay and allowances by allowing individuals to complete training sooner and report to duty stations earlier and could also be used to offset training resource shortfalls.

Up-front costs are required. Although TRADOC can expect significant cost savings/avoidances by using dL, the up-front costs to install and implement dL capabilities are substantial. Savings through dL can return these initial costs quickly, as early as 2 years in some analyses; however, to develop and implement dL capabilities, TRADOC will require initial investment resources not currently budgeted.

Quality of dL instruction matters. The effectiveness and acceptability of dL courses depend on the quality of their content and instructional approaches. If the quality of instruction is poor, anticipated returns from resources invested in dL will fall far short of expectations. The dL instruction needs to be appropriately adaptive. Basic principles of learning and motivation should be as carefully considered in the design and development of dL as in any other form of training. The technology delivering dL must be reliable, user friendly, and bug free. In general, routine, impartial, and periodic assessments of quality are as essential.

Cultural barriers will have to be overcome. Changes in well-understood and hard-to-acquire techniques and procedures are never popular. Hands-on involvement by senior leadership will be needed to overcome organizational reluctance and cultural barriers. Overcoming these challenges will require conscious, resource-consuming efforts to educate and demonstrate the potential value of dL to opinion makers at all levels—especially to the mid-level leaders on whom the burdens of change may fall most heavily.

Techniques of change management are known and available. TRADOC will need to establish incentives and rewards for early adopters. It will also need to ensure that adequate infrastructure for developing, revising, and maintaining dL technology and materials are in place when dL is implemented. Finally, TRADOC must establish sufficient cooperation between Army training and personnel functions to ensure that individuals who pursue dL learning (especially its anytime, anywhere capabilities) are rapidly rewarded for their efforts with assignments and responsibilities suited to their training accomplishments and commensurate with their newly acquired abilities.

Instruction chosen for dL presentation must be carefully selected. Selection of dL materials should take place at the learning-module level rather than the course level. Smaller and more homogeneous modules of instruction are more unambiguously assigned to media and are more easily reused in combination with other modules to create new courses of instruction.

The basic approach should be to decide what cannot be taught as dL rather than to decide what can. This analysis should involve school and proponent personnel. Blended learning, with both residential classroom instruction and stand-alone dL, is likely to be a preferred approach. The analysis should include input from civilian experts/consultants who have experience in identifying and determining potential dL challenges/solutions. dL modules that have similar training matter and similar objectives should be identified within and across schools for attention

and management by a single proponent. Microsoft has found four types of instructional applications to be most amenable to dL:

1. assessment of prior knowledge and skills,
2. acquisition of declarative knowledge,
3. reinforcement of declarative knowledge, and
4. introduction of low-level tactical knowledge.

Second- and third-order dL effects will occur. Introduction of dL will create inevitable ripple effects—some beneficial, some not. Prudent selection of learning modules for dL presentation and delivery will help identify and eliminate duplicate modules, thereby reducing costs. Training and performance commonalities between active and reserve components will help improve interoperability and operational readiness/effectiveness. Budget metrics, especially those keyed to instructor contact hours, may need to be modified for dL applications. Personnel orders and assignments will need to take into account course completions and skill certifications that can occur at any time. The cost benefits of dL delivered remotely to dispersed individuals in units and duty stations could motivate the undue replacement of f2f, residential instruction, with insufficient consideration of the interpersonal, social, and cultural benefits arising from the latter. The reduced need for standard classrooms and classroom instruction may affect military installations and local economies.

Evaluation must be integrated with dL. An assessment of the costs and effectiveness should proceed hand-in-hand with the design, development, and implementation of dL. Spiral development with periodic, formative evaluation can help ensure that dL initiatives are doing things right and doing the right things. Cost models with well-defined and agreed-upon cost elements will be needed, as will analogous models for the competencies being sought. Both models should be used to provide common ground in comparing costs and effectiveness across training alternatives. Also, tacit knowledge (knowledge that is not easily articulated nor readily classified as either declarative or procedural) and meta-cognitive skills (roughly, the ability to assess and manage one's own thinking) may be critical aspects of military planning and decision making. Research should be undertaken to measure their roles in cognition and their development and attainment through training. Overall, systematic and periodic analysis to identify and review measurable training objectives, standards, and conditions will be necessary.

Supervisors must explicitly allow time for dL training. Because dL can be accomplished anytime, anywhere, it is often left to be completed transparently—invisible to supervisors despite continuing duty station and family demands on learners. If supervisors do not allow time for dL training, this may seriously affect the quality of life for Soldiers and will fail to encourage the professional growth that is essential to adaptive, successful organizations. Explicit (usually written) agreements between supervisors and subordinates can successfully establish and preserve time needed for the professional growth available from dL and avoid deleterious affects on a Soldier's quality of life. Army leadership should support such agreements.

Both learners and instructors need training in dL. Because of the adaptive, individualizing nature of dL, learners are commonly given more control over their course progress and objectives than they are given during classroom learning. Learners need to

understand the freedoms and the responsibilities that come with dL. Similarly, instructors must learn how best to integrate dL into their classroom instruction. It has become a cliché to describe instructor roles in dL as a shift from "sage on the stage" to "guide on the side," but this point of view appears to hold some credibility. Instructors are needed, but dL requires that their roles change. They may need training to learn these new roles.

Different training approaches are needed for different training objectives. Different models for directing learning are needed to train the Art and Science of War. For instance, a more directed approach, such as that emphasized in the GEL model, seems likely to enhance effective and efficient learning of basic declarative knowledge, such as facts, definitions, simple concepts, and routine procedures. Less direction and more freedom to explore and experiment may be needed for learning "higher order" cognitive processes, such as complex troubleshooting, decision making, planning, critical thinking, and leadership, which emphasize developing the general problem-solving capabilities of learners. Guidelines for approaches in both areas of learning are now available and provide a foundation for staff and faculty training programs already under development.

What Works

Several Department of Defense (DoD) programs are showing promising results for dL. These include the Navy ILE, Army National Guard dL training, the United States Marine Corps (USMC) Tactical Leader Games, "Role Guides" for Air Force Civilian Competencies, and programs such as Nova University's Distance Learning Leaders' Certificate Program for educating senior leaders on dL. In addition, findings from over 200 empirical studies comparing adaptive dL technologies and classroom instruction suggest that dL can increase learning and reduce the time and the costs to learn.

What We Don't Know

How dL works. Data collected on dL attest to its effectiveness and cost savings. However, statements based on these data only summarize the statistics. They do not address cause and effect. We need more understanding of how dL works and how it should be designed and implemented if it is to produce reliably the results we seek. Frameworks such as GEL provide foundations for the necessary investigations. Basically, dL technology allows us to control learning environments more precisely and consistently than is possible in instructor-led classroom instruction. Adaptive dL technology may enable an "engineering" of training that allows every student to attain targeted training objectives reliably and efficiently.

How to effect large culture change. As noted previously, dL will encounter cultural barriers. These barriers must be overcome quickly if dL is to be implemented in time to relieve pressures arising from diminishing training budgets and resources. We need to understand better how to change the cultural climate of Army training so that it becomes hospitable to dL. Study of existing institutional, organizational, and budgetary incentives and disincentives for dL should focus on defining the problem more precisely and identifying solutions that can be implemented.

How to balance remotely provided dL and f2f instruction. The interpersonal and social contacts (e.g., peer interactions, bonding, socialization, direct exposure to role models, and so forth) that grow out of f2f experiences remain essential components of Army training. Despite the availability, capabilities, and benefits of dL, these components must not be abandoned. We need to learn more about how to preserve and encourage interpersonal and social contacts within dL and how best to balance training activities and allocate resources between remotely delivered dL and f2f training experiences.

Potential Impact

Use of dL can accelerate training, reduce costs and personnel requirements, and improve operational effectiveness without adversely affecting Soldiers or their families.

How Can the Army Streamline Institutional Training Courses and Align Them Better With the Needs of Operational Units?

What We Know

TRADOC successfully produces trained Soldiers and adaptive leaders. The working group noted that TRADOC was performing its training mission effectively and that the current emphasis on producing a Generating Force closely linked to the Operating Force is an appropriate, necessary direction for TRADOC transformation.

A natural tension exists between TRADOC's institutional responsibility and the needs of operational forces. TRADOC's business is to encourage and support the acquisition of widely transferable knowledge and skills to sustain professional growth. Training in the operational forces often and necessarily emphasizes agile, short-term solutions to immediate needs. These differences create a natural, continuing tension. Developing a proper balance between these two training missions (short-term vs. long-term needs) requires mutual trust, cooperation, and coordination between TRADOC and the Operating Force.

Ways are needed to link the immediate training goals and current duty assignments more effectively. One constructive recommendation is the use of dL linked to personnel databases. This would enable individuals to train for specific duty assignments so that they arrive in theater more fully prepared for immediate duty.

Assignment-oriented training (AOT) based on equipment and/or theater can reduce course times to completion and costs. Using dL to tailor training to the specific needs of the individual and his/her duty assignments can reduce course lengths and training costs. Such training requires a balance between training for specific operational needs and training for long-term professional growth.

Some resident institutional training can be delivered in units. Appropriate use of mobile training teams, cost-effective application of unit training resources, and, especially, the anytime, anywhere capabilities of dL allow portions of resident, institutional training to be delivered to units and duty stations. Some available information suggests how best to allocate training

responsibilities between residential and unit settings, but more needs to be done to rationalize the allocation of learning responsibilities between residential and unit settings. A generally applicable, cost-effective, and operationally effective means for allocating training responsibilities between residential and unit training needs to be developed. It will require the development and integration of cost models, human performance models, and unit effectiveness models.

Increased use of performance aids can reduce the demand for training. Much is learned through training, and much is forgotten after training. Performance aids can be used to refresh previously learned skills. Training research and development (R&D) focuses primarily on increasing the supply side of training. Performance aids and decision aids can reduce the demand side of training by assigning some portion of learning to performance aids. The state of the art provides considerable information about designing training and performance aids. What is needed are generally applicable techniques for deciding what performance requirements should be allocated to performance aids, what should be allocated to training, and how to best (cost effectively) integrate training curriculum and performance aid designs. Because the underlying knowledge structures for training and performance aiding are similar, both can be readily incorporated into the same dL platforms. The incremental costs for building performance and decision aids on top of dL training or for building training on top of performance aids are small.

The Army could require Soldiers to complete annual "Continuing Education Units (CEUs)." One way to encourage professional growth is to require every Soldier to complete a program similar to the CEUs offered by business organizations and academic institutions. The anywhere, anywhere capabilities of dL would make this requirement reasonable and feasible. The dL capabilities would also allow this requirement to be tailored to an individual Soldier's occupation, skill level, career growth, and duty assignment(s)—assuming sufficient cooperation and communication between training and personnel functions can be established.

dL authoring tools should be available for use by local commanders. Nearly all Army operations encounter unexpected and unanticipated challenges. One way to prepare for these challenges is to ensure that capabilities for preparing or editing dL, simulations, and/or simulation scenarios are available to local commanders in a format that does not require substantial computational skills. In dL, this capability takes the form of "authoring tools." The term appears to apply equally well to simulations and simulation scenario preparation. These tools should be available to operational force leaders whenever and wherever they are needed. Such tools are equally useful for institutional training and can streamline the design, development, and delivery of training in both settings.

What Works

Programs that work to streamline courses include the Navy IEL, Advanced and Enhanced Basic Combat Training at Fort Jackson (South Carolina), and Stryker University.

What We Don't Know

Ramifications and effectiveness of an AOT program. An effective AOT program will require more cooperation and communication between personnel and training functions. Currently, these two functions are too "stove piped." However, all the technical problems (e.g., ways to communicate effectively between databases) can be solved by the current state of the art. The more pressing challenges are organizational, structural, and administrative. Senior Army leadership must create incentives to ensure the necessary communication and cooperation. From a training standpoint, the main difficulty is to develop widely applicable techniques for individual training programs that balance the needs of individual Soldiers for both long-term professional growth and short-term duty assignment competencies.

Given ARFORGEN, is there still need to train the 40/11 warrior tasks and drills in Initial Entry Training (IET)? ARFORGEN is intended to provide a steady, continuous supply of rapidly deployable, employable, and sustainable force capabilities tailored to specific mission requirements. It may ease demands on IET. To determine the implications of ARFORGEN on IET, specific review and analysis are needed.

How best to assess Soldier needs and tailor courses to these needs. Many formal and explicit methods (e.g., testing) are available to assess a Soldier's prior knowledge, abilities, and interests. Techniques to assess these characteristics implicitly an from an individual's routine interactions with technology might be developed, but the degree to which this can be done, the assessments that will still require explicit testing, and cost-effective tradeoffs between the two need to be developed. Once a profile of a particular Soldier's knowledge, abilities, and interests is available, much still remains to be understood about how to use this knowledge to tailor course content, structure, pace, sequencing, and, perhaps, style for that Soldier. Available information indicates that tailoring course content using dL technology will reduce the time and cost needed to achieve training objectives, but more information is needed. Better and more systematic tailoring—better individualization—of instruction may further increase these time and cost savings.

Potential Impact

Streamlining Army courses will accelerate training, reduce costs, and reduce personnel requirements.

How Should the Army Prepare Learners, Instructors, and Training Developers To Make the Best Use of New Training Technologies and Approaches?

What We Know

Learners, instructors, and training developers all need training in using dL. Because of the adaptive, individualizing nature of dL, learners are commonly given more control over their progress and objectives than they are given in classroom learning. Learners need to understand the freedoms and the responsibilities of using dL. Similarly, instructors must learn how best to integrate dL into their classroom instruction. These instructors remain essential, but research

indicates that their roles must change if they are to use dL successfully. Instructors need to learn how to integrate these new requirements into their roles as teachers. Training designers and developers also need to understand how best to use the strengths of dL training technologies, training approaches, and authoring tools, how to match dL technologies and approaches to desired training outcomes, and how to tailor dL to an individual Soldier's knowledge, needs, and interests.

In general, dL training is more like individual tutoring (one instructor working with one student) than the classroom instruction with which most students, instructors, and developers are familiar. Research has shown individual tutoring can be a powerful instructional technique, but it is prohibitively labor intensive and expensive in most cases. Computer technology makes many aspects of individual one-on-one tutoring accessible and affordable, and learners, instructors, and training developers need to use this significant instructional capability to the Army's best advantage.

A training and training development support system is now feasible and affordable. Because the development and delivery of dL requires different knowledge and skills than those needed for classroom instruction, a support system is required for learners, instructors, and training developers. State-of-the-art dL information suggests how such as system could help identify and support communities of practice that meet face-to-face or operate at a distance. The system could also provide sample models of excellence, mentors and coaches, a common repository of templates and other authoring tools. It could also provide an opportunity for continuing professional development in areas such as learning theory, techniques of instruction, individual assessment, and educational technology. Finally, the system should encourage interdepartmental communication, cooperation, and coordination within and between schools.

What Works

Successful academic and industry dL instructor training programs on which the Army could build are available.

What We Don't Know

What are effective and sustainable "train-the-trainer" tools for dL instructors and training developers? This issue is not simply a matter of knowing how to create effective and sustainable tools because enough information appears to be available to produce good first efforts. The real issue is getting this done. An adequately resourced effort needs to be undertaken for Army dL training.

Should we spend more or less on training development? Training is a means to an end. It helps ensure the availability of necessary levels of human capabilities when and where they are needed. Many factors (e.g., recruiting, selection, job classification, assignment, ergonomic design of equipment, career design, and training) contribute to producing the human competencies needed for successful Army operations. These factor are intertwined. Higher standards for selection reduce demands on training capabilities and resources. Better ergonomic design of equipment and more precise classification of individuals into career fields will reduce

demands on training. How, then, should investments in these areas be allocated to get the best results? More directly, when is a problem a training problem and how might we determine the military value of training? These are critical issues, but they are not addressed well—if at all—by Army manpower, personnel, training, and acquisition management. The Manpower and Personnel Integration (MANPRINT) program is a start, but more (e.g., the development of an adequate HPI model) needs to be done. The payoff from answers to these tradeoff questions may be significant and, at least, will help to ensure best use of scarce resources.

How should the Army ensure quality control (QC) when contracting for dL development? Contracting must accommodate the fact that dL development requires a team approach that includes subject matter experts (SMEs), instructional designers, graphic artists, software technicians, and performance measurement specialists. That said, several questions about contracting were raised but not answered:

- What issues should be addressed in an effective statement of work (SOW) to ensure the production of good quality materials?

- How should the review and assessment of interim prototype training materials be scheduled and performed in the course of spiral development?

- How much formative evaluation is enough?

- What are the tradeoffs between QC production costs and assurances?

Partial answers to these questions abound, but more complete answers are needed to manage the contractual development of dL materials most effectively.

Potential Impact

Training in dL is an important issue. It can make or break dL's acceptance and use and the many benefits it offers Army training effectiveness and efficiency—especially those benefits it offers for increasing Army operational effectiveness through improved human performance and competence.

V. DEVELOP LEADERS WORKING GROUP

For several years, the U.S. Army has recognized the need to develop self-aware, adaptive leaders who can perform effectively in a broad range of situations across the full spectrum of operations. This working group began by examining a set of questions about leader development and the need for practical recommendations that General Wallace, TRADOC Commander, emphasized in his workshop guidance.

The group had wide-ranging discussions about definitions of leader development and core leader competencies. Those discussions pointed out the different levels of leadership and the differences in required behaviors while also emphasizing how Army leader responsibilities are evolving downward to more junior Soldiers. The group discussed what we know about measuring effectiveness and quality but had inadequate time to discuss the measurement question. The emphasis focused on three major issues/questions:

- What is the process of forming personal and professional relationships within the Army (i.e., socialization)?

- What are the characteristics of adaptive leaders and individuals?

- What are some strategies to accelerate growth in adaptive behavior?

For each of these questions, the group summarized what we know, what works, what we don't know, and potential impact (value added) of proposed solutions.

Overall, the key points were as follows:

- The socialization process can positively affect leader development.
- Adaptive performance can be developed and trained.
- Leader growth can be accelerated.

What is the Process of Forming Personal and Professional Relationships Within the Army (i.e., Socialization)?

What We Know

Socialization is a process that focuses on bringing new people (entry level and leaders) into the existing organization. It is about forming personal and professional relationships. The purpose is to make organizational members stakeholders through a process of cultural change. Figure 7 illustrates many socializing agents at work together. Socialization affects and is effected by self-identity, values (e.g., warrior ethos), knowledge of the organization, language of the organization, knowledge of the existing networks, and organizational history. Socialization requires that a unit's leader and the personnel in that unit adapt. Components of socialization include

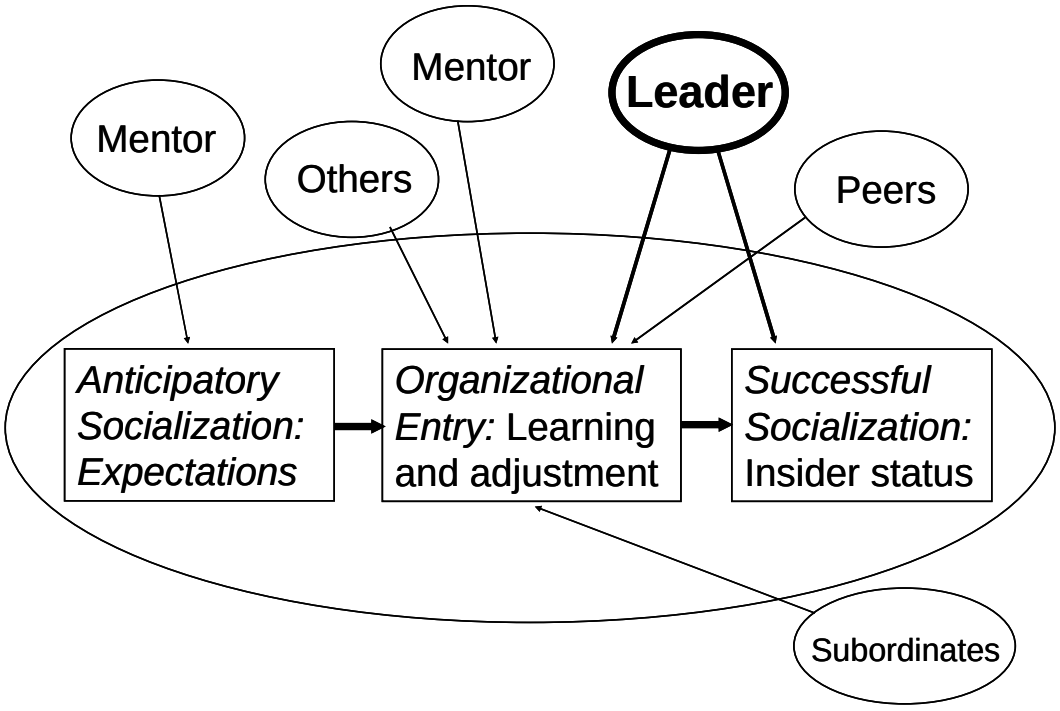

Figure 7. Leadership, developmental networks, and organizational socialization (Source: Chao, 2007).

- Anticipatory Socialization: the expectations you have going in.

- Organizational Entry: the smoothness and structuring of your early experience within the organization. This involves a sense of self and how well you are viewed by others.

- Successful Socialization: The resulting quality of your "insider status."

Individuals who are not able to socialize successfully are likely to leave the organization. Several guiding principles are part of the process:

- Socialization happens whether one likes it or not.

- Leaders play a strong role in the process of socializing new organizational members (small unit, Big Army) and serve as a model of how to perform.

- Early, challenging assignments and mentoring lead to more effective organizational socialization.

The Army has a vital role in successful socialization. For example, the Basic Officer Leadership Course (BOLC), the Captain Career Course (CCC), the School for Command Preparation (SCP), and the Warrior Leader Course (WLC) prepare leaders to leverage/influence the natural socialization process. Fundamentally important is linking Soldiers together so that they can be influenced by all levels of Army leaders who provide consistent and clear guidance.

That happens in many ways (e.g., face-to-face during initial military training, during unit training, and as part of Army socializing and lifelong education). One newer way to meet is through on-line social networking technology [e.g., myspace.com, Army Knowledge Online (AKO)]. On-line technology can assist socialization by *augmenting* f2f interactions in the relationship-building process although the capability or desire to access this technology varies across generations.

What Works

Four Army approaches to socialization were identified as models for what works and, therefore, should be used as a foundation for improving the overall process:

1. *The program at the 1st Brigade, 25th Infantry Division Stryker Brigade Combat Team (1/25 IN SBCT).* This program works because its leaders understand the need for agility, adaptability, and synchronization of all elements. The leaders provide training in (a) the use of the organization's digital strengths, (b) combined arms capabilities down to the platoon level, and (c) available intelligence surveillance and reconnaissance assets to fight the enemy differently than before. They train to see first, understand first, act first, and finish decisively (Brown and Sims, 2005). The leaders are aware that they must assimilate Soldiers from other units into new ways of thinking and performing operations. All personnel take time to train how to frame a mission, how to complete the mission, and how to "think outside the box."

2. *Formalized unit reception and orientation programs.* These programs work because they provide structure and organization that introduce Soldiers to their new assignments.

3. *The Army Materiel Command's (AMC) civilian Greening Course and Intern program.* This program works because it allows the entire Army family to share a common culture—its organizations, equipment, terminologies, and traditions.

4. *Role modeling/virtual staff ride or virtual right seat ride (vRSR).* These approaches work by allowing a unit's leadership pre-prepare for deployment better than they can prepare with standard training. They view the electronic feed from the ongoing operations of the unit they are to replace to understand the environment and situation before their unit arrives.

Industry also has experience achieving socialization through mentoring, and the Army should consider adapting this experience to its needs. New employees share a common need to learn about the company and to bond with fellow employees. At IBM, a mentoring program called Connections is designed to help new employees join the team quickly and effectively. The program is structured to help new employees in two key ways: develop their business effectiveness and establish a good social network with their manager and colleagues.

IBM encourages all employees to have mentors so that they can learn from others. In fact, most people benefit from having several mentors in different areas (e.g., career growth,

technical knowledge, and business and client awareness). Employee requests to continue the program are testimonies to its success.

The collective findings about "what we know" and "what works" suggest that achieving socialization is complex. Course modules about socialization are only one component. The Army needs to demonstrate repeatedly to recruits, new Soldiers, and careerists that socialization in the Army family is important. Socialization must reinforce and support desired Army goals and capabilities.

What We Don't Know

Although we know what socialization is and some ways to achieve it, important aspects must still be clarified for inclusion in a comprehensive Army program. The Army needs a set of intended outcomes and goals for socialization processes and metrics to measure success. Leader development experts must determine specific tools for leaders to leverage socialization for (1) supporting the development of organizational and individual adaptability and (2) effecting organizational change more generally. One of the most promising contemporary tools for leaders and Soldiers in fostering socialization may be on-line/network-based socialization, but we have questions about how effective it can be. For instance,

- What are the time requirements for different socialization methods?
- How much of early socialization can be managed through on-line interactions?
- Does professional interaction within communities of practice lead to effective socialization?

Potential Impact

The socialization process can help a commander achieve organizational change. The cost effectiveness is excellent since most inputs, including clear communication, consistency of message and action, and the leader as a role model, are possible at little or no cost.

What Are the Characteristics of Adaptive Leaders and Individuals?

What We Know

Adaptability is the ability to change strategy or behavior effectively during actual (or anticipated) altered situations. Adaptability is an integral part of being an Army leader. It leads to growth and change throughout careers and enables rapid adjustment to battlefield situations. This need is particularly acute in the unstable environments of the war on terrorism. Therefore, adaptability has become a critical attribute of good leadership and is required increasingly for more junior levels in efforts to cope with changing, diverse, and unpredictable environments.

Much of the writing about adaptive leaders (e.g., Fallesen, 2006) describes their multidimensional characteristics according to what we expect leaders to do. Field Manual

(FM) 6-22, *Army Leadership – Competent, Confident, and Agile,* provides a comprehensive basis and listing of Army leader characteristics as an enduring core set. Leaders differ from one another in terms of strengths and weaknesses. Jobs for officers, noncommissioned officers (NCOs), and warrant officers and the ranks within each differ because of skill, knowledge, and behavior requirements and the nature of the situation at hand. Adaptability requirements will differ because of a leader's job and level.

Fallesen asserts that core competencies remain constant but that shifts occur in the application of competencies. He illustrates how the differences in levels of leadership—direct, organizational, and strategic—have an effect on a leader's scope of influence, the time horizon, and what's at stake. For example, leaders communicating at the direct level need to ensure shared understanding, leaders communicating at the organizational level need to inspire through choice of message and approach, and leaders communicating at the strategic level provide symbolic themes and multipurpose messages. The Army should adapt its learning methods and technologies to be consistent with the degree to which leader characteristics differ.

Many characteristics apply to leaders at all levels, with modification in meaning and implementation. Figure 8 presents an example of what characterizes a mentally agile leader—a category that subsumes the adaptable leader. Everyone is adaptable at one level or another, and everyone's behavior can be influenced in several ways: through education and training, through how well an organization's climate and systems accommodate it, and by including individual capabilities, experiences, and job requirements into expectations.

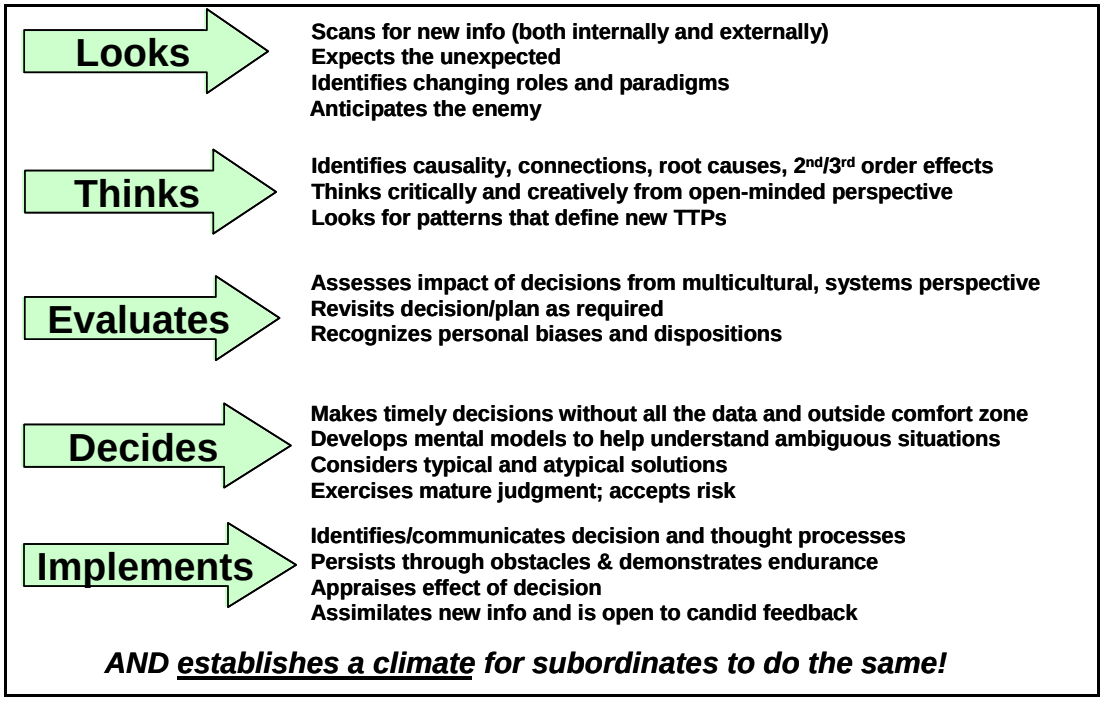

Figure 8. Model of the mentally agile leader (Source: Bullis, Gerras, and Wong, 2005).

Because of differences among leaders and their jobs, selection and training procedures must be tailored accordingly. Figure 9 illustrates different kinds of adaptive performance and the skills that we know support such behaviors. Successful training approaches must be flexible in dealing with leader differences and must teach adaptive procedures. To do this, we need to give leaders some experience within real or artificial scenarios that encourage exploration, provide feedback, allow failure and problem solving, and link requirements of the situation to appropriate procedures and content themes.

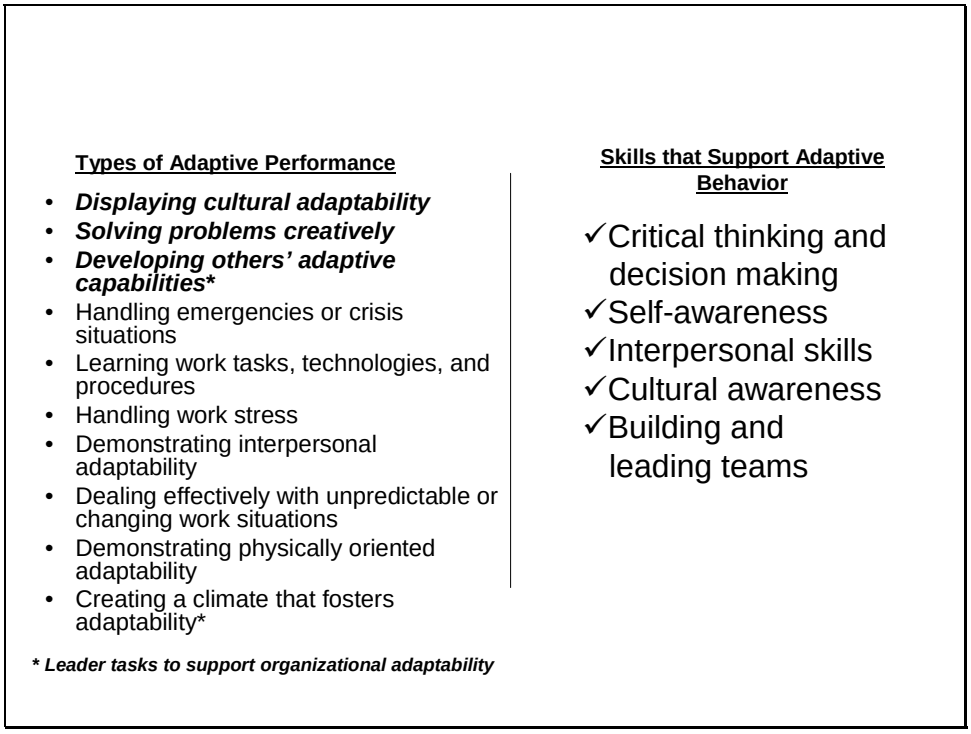

Figure 9. Adaptive performance and supporting skills (Source: Dorsey, 2007).

What Works

We have strong data on predicting adaptive performance through the use of individual and team characteristics. For example, we can predict who is likely to be adaptable by combining adaptability predictors (e.g., those in Figure 9) with measures of cognitive ability, personality, and experience (Pulakos, Schmitt, Dorsey, Hedge, and Borman, 2002; Dorsey, 2007). Some programs also successfully target adaptability training. The U.S. Army War College has a program in Leadership Adaptability. The Special Forces—for team leaders and warrant officers—and Civil Affairs/Psychological Operations (CA/PSYOPS) provide excellent mental and interpersonal training in adaptability and in experience leading adaptive teams.

What We Don't Know

Although we have identified many different kinds of adaptability and skills needed for successful performance, we do not know the adaptability requirements necessary for different levels and positions. Similarly, what does a progression of adaptability training look like? Can adaptability development started in one context/performance domain be continued successfully

in other domains? Also, once a leader has achieved adaptability in one context, will that be useful in other contexts?

From a different perspective, we also do not know if potential negative outcomes may arise if too much adaptability training and individual adaptation takes place. For example, a General Motors' (GM™) employee in China was said to have "gone native" (i.e., he made decisions more in China's best interests than GM's).

Potential Impact

The Army has to inculcate in leaders at all levels a generic capacity for adaptability because this is the only way to extend training to great numbers and types of situations. Therefore, having more adaptive leaders should lessen the burden on training systems. It also should increase the potential for Soldiers to cope with change and stress. Overall, adaptive performance is the only practical way to leverage our preparations for achieving success in changing contemporary and future operating environments.

What Are Some Strategies To Accelerate Growth in Adaptive Behavior?

What We Know

A repeated question in the working group was not just what to do but how to do it, and particularly, how to accelerate adaptive behavior. The principles are familiar:

- Begin with a sound foundational knowledge of the job
- Practice with varying challenging conditions and provide time for feedback and reflection
- Establish a work climate that supports innovation, autonomy, and freedom to fail
- Learn from the experience of others and from daily events
- Identify with being an adaptive leader, emphasizing improvements in critical and creative thinking.

To grow adaptive behavior faster, the leader must focus on the development of conceptual skills and practice them for quick assimilation of diverse information. For example, a leader must question assumptions, always be alert to the need for change, study a problem from different perspectives, and mentally simulate/visualize the details (e.g., precision of inputs, consequences of actions, and timeline). Above all, a leader must have a strong motivation to practice.

What Works

At least three approaches illustrate how to accelerate adaptability:

1. *Georgetown University's Army Reserve Officer Training Corps (ROTC) Adaptive Leader Course (2001–Present).* This course uses the Pestalozzi[3] learning method that emphasizes "experience the thing before trying to give it a name." Components of the curriculum include scenario and case studies, tactical decision-making games, and free play force-on-force. Feedback employs 360-degree multirater assessments[4] of how others (superior, team members, peers, and subordinates) perceive the leader's effectiveness—strengths and weaknesses. Aspects are being used in Army BOLC II.

2. *The Special Forces Adaptive Performance Model.* The intent of this model is to make adaptive performance requirements clear by job and level and sometimes even by individual. Developmental interventions include combinations of tools such as experiential learning, deliberate practice, rich organizational support, and feedback mechanisms. Similar to Georgetown's ROTC course, this model makes use of multirater assessment and feedback.

3. *Agility Module in the CCC.* At Fort Benning (Georgia), a pilot test is being conducted based on recommendations from the Army War College's Agile Leader Study. An Agile Leader module begins on the first day of the CCC, with 3 days to shape learning. Topics include critical and creative thinking, negotiations, decision making, vignettes, practical exercises, and self-awareness through 360-degree assessments. Instructors reinforce mental agility throughout the CCC.

In addition to these formal approaches, informal experiences that require adaptability also have a role in accelerating growth. For example, to speed up cultural adaptability, we could embed leaders in foreign cultures to do recreational activities (e.g., backpacking with foreign nationals). As alternatives, we could provide officers the opportunity to work with non-governmental organizations (NGOs), at the Department of State, or at an Embassy. Given the opportunity, everyone can be adaptable at one level or another.

What We Don't Know

The problem we face is "How much can we do"? Four questions often raised are

1. How is growth affected by emotional processes (e.g., orientation to change)?
2. What are the limits on accelerating growth?
3. How do we identify when is a person ready to learn?
4. What are the optimal intervention points in a person's career for what interventions?

[3] Johann Heinrich Pestalozzi (1746–1827) was a Swiss educational reformer. He put Jean Jacques Rousseau's theories into practice and thus became the first applied educational psychologist. Pestalozzi believed that thought began with sensation and that teaching should use the senses.

[4] A 360-degree leadership assessment of officer effectiveness uses peer and subordinate input.

In addition, the working group discussed issues with using 360-degree feedback. It needs to be done early before a leader's ways are set. However, how do we know when a leader is ready for it? We also do not know how to ensure that feedback of this kind about the person—contrasted with task performance—will be accepted at face value. Therefore, to achieve maximum effectiveness, should 360-degree assessment data just be given to a person, with little feedback and, therefore, allowing him/her to interpret the assessment, or should it be given by trained, competent mentors who can offer constructive explanations/inputs in the total evaluation process?

Potential Impact

Any acceleration in growth of adaptive behavior has obvious benefits. It produces leaders who can assume increased responsibilities sooner and who are better prepared for the full spectrum operations.

VI. FUTURE CAPABILITIES WORKING GROUP

This group envisioned what learning science and emerging technologies will offer within the next decade and articulated how the Army might train Soldiers and develop leaders more effectively. To frame the discussion, the facilitator posed the following open-ended questions:

- How can training, leader development, and self-development be managed as one integrated system across a Soldier's career and in a variety of environments?
  - How should the approach vary for enlisted Soldiers and officers?
  - How would this system work with the personnel system for promotions and assignments (in an ARFORGEN Army)?

- How can future embedded training systems be designed and used to provide effective training?

- How can emerging technologies be leveraged to
  - accelerate learning and improve effectiveness?
  - incorporate lessons learned from operational environments?
  - automate measurement and feedback, especially for complex tasks and collective performance?

The Future Capabilities Working Group focused less on "knowns" and more on "unknowns." To recommend a coherent R&D program, relevant assumptions and preconditions had to be identified. The group began by addressing the following question: What are some considerations that underlie recommendations for future R&D? The discussion of this question centered on identifying some general assumptions about the future, identifying some attributes of the future warrior, and examining some overarching R&D issues.

What Are Some Considerations That Underlie Recommendations for Future R&D?

Assumptions About the Future

Working group members identified six key assumptions about future warfare and the battlespace:

1. *Decision making at lower levels.* The military panelists emphasized repeatedly that decision making is being pushed downward, noting specifically that Captains now are forced to make decisions that had been the responsibility of Lieutenant Colonels. To ensure that all Soldiers are prepared to make sound decisions when required, training must take place at the most junior levels of leadership (e.g., the "strategic corporals" who will be manning checkpoints and must make critical decisions rapidly without having been able to consult more senior leaders.) This trend implies that Soldiers need complex skill repertoires earlier in their careers.

2. *Importance of cultural and social skills.* The importance of developing good cultural and social skills—including expertise in group dynamics—increases as joint and combined

operations become more common. These skills are especially necessary when a Soldier has to interact with military personnel and civilians from foreign governments and or with U.S. personnel from governmental organizations and NGOs. These skills also apply to interactions within teams, where the need for decisive leadership must be balanced against the need to hear and apply advice from all team members.

3. *Rate of change.* Not only is the content of training undergoing fundamental change, but the rate of transformation will also be increasing. The group assumed that the rate of change will increase exponentially with increasing complexity.

4. *Lifelong learning.* Continual learning throughout a Soldier's career will become increasingly important. This will have to be individualized/personalized learning and will require the development of learner-centric models of instruction. Training a Soldier how to learn in unsupervised settings may also be necessary (i.e., "learning how to learn" becomes a competency in itself). For lifelong learning to be most effective, the need for rapid and continual performance assessment of individuals, teams, and small units will increase. This implies that knowledge management (at unit and Soldier levels) will become more important.

5. *Unmanned systems.* The incorporation of numerous new unmanned devices and systems onto the battlefield will blur the distinction between training support and Army operations.

6. *Access to knowledge.* The increased openness, quantity, and interconnectedness of information will continue, with knowledge becoming more distributed.

Attributes of the Future Warrior

The discussion about the future warfare and battlespace implied that tomorrow's warrior must have a new set of attributes and competencies, which include the following:

- *Decision-making skills.* Knowing not only what to do, but also when to do it. Soldiers need to balance two needs: the need for decisive, automatic action and the competing need for judgment arising from situation assessment and analysis.

- *Social/interpersonal/cultural skills.* Communicate and work effectively within interservice and interagency (as well as foreign) environments. Soldiers must know how to provide decisive leadership while encouraging and applying relevant advice received from subordinates.

- *Lifelong learning.* Commitment to assume responsibility for personal learning and development. Soldiers must acquire the necessary skills to do their jobs and be willing to update these skills as their positions evolve or as they assume new positions of responsibility.

- *Technological savvy.* Possess the knowledge, skills, ability, and adaptability to learn, operate, and troubleshoot new and constantly evolving technologies. Soldiers must keep abreast of technological advances by taking advantage of training and educational opportunities. The future Army will require that Soldiers be technologically proficient.

- *Comfortable with complexity and uncertainty.* Possess reactive and deliberative decision-making skills required to cope with uncertain and unexpected situations requiring rapid and imaginative adaptability. Soldiers must develop the skills necessary to survive in today's increasingly complex military environment. These skills can be acquired through on-the-job training (OJT) or through continuing education programs.

Overarching R&D Issues

Working group members agreed with the general assertion that R&D provides the means for meeting the challenges of future warfare. Four R&D issues were considered:

1. *Constrained resources.* How do we promote the acquisition of expertise in a time of constrained resources? The trend is toward fewer trainers in institutions and the field and less time spent in institutional training. The training community must learn to make the case for an ROI from training and a case for its military, operational value.

2. *Embedded training.* How do we exploit the concept of embedded training to make instruction accessible without incurring the cost of special training infrastructures? New approaches that integrate embedded training and operational systems must be developed.

3. *Acquisition of expertise.* Expertise is usually acquired over decades of structured experiences. New methods are needed to compress the time needed for experiential learning and for acquiring the skills and bodies of knowledge that comprise expertise.

4. *Right kind of practice.* Technology is needed to guide practice and provide feedback in the institutions and in the field. The opportunity for practice will be at a premium and will require the development of low-cost, more efficient and effective training and progress assessment tools.

After this initial discussion, the group identified and discussed research questions that offer a large potential payoff for the Army:

- How can we individualize training processes based on performance assessment and management (i.e., individualization of training processes for Soldiers, teams, and small units based on performance assessment and management)?

- How do we provide relevant knowledge-based training support (i.e., relevant training support through management of knowledge and tailored training approaches)?

- How do we develop low-cost, effective training tools (i.e., rapid development of low-cost, effective training tools for individual, team, and small unit training)?

For each of these questions, the group summarized what we know, what we don't know, future applications, and what research is needed.

How Can We Individualize Training Processes Based on Performance Assessment and Management?

The challenge of this initial question can be extended as follows: How can we manage training, leader development, and self-development as one integrated system across a Soldier's career and a variety of environments?

What We Know

We know that timely assessment and feedback—the foundations of an individualized training program—can affect performance positively. We need improved methods and tools, including automatic collection of outcome measures, to make assessments easier to administer, interpret, and use.

What We Don't Know

The discussion revealed that much more needs to be learned about automating the process of assessing and managing training progress. Specifically, we don't know how to

- collect process measures automatically;
- aggregate system data to reflect complex processes;
- integrate performance measurement and tailored instructional delivery;
- provide automated delivery, assessment, and management of embedded training; and
- provide a generalized means of aggregating training data to support automated collective performance assessment.

Future Applications

Through research, advanced technologies that allow training to be tailored to specific individuals, teams, and small units can be developed. Each Soldier has unique prior knowledge and experience, beliefs, attitudes and interests that motivate him or her, and each has competing demands on his/her time and attention. Research has found that assessing these characteristics and then tailoring training content and sequences an individual's profile can produce significant reductions in time to learn and time needed to achieve training objectives. The teams and units that comprise collectives of Soldiers also differ. For the Army, producing more effective and efficient "accelerated" learning is dependent on its ability to assess and accommodate basic Soldier and team dimensions.

Improved embedded training systems can provide realistic environments for off-line distributed training, without requiring a dedicated training infrastructure. Embedded training can also be used during operations to provide on-line performance support and can also help ensure that no systems or system modifications are fielded without the training needed to operate, maintain, and deploy these systems.

What Research is Needed

To facilitate development of these future applications, the following lines of research need to be pursued:

Automated instructor functions. Embedded and other forms of distributed training present a challenge for instructor processes. We must investigate to what extent automated systems can be used to provide coaching, mentoring, red teaming, and instruction management processes at a distance.

Methods to prescribe training. Given procedures that can accurately assess a learner's current state of knowledge and ability, methods are needed to prescribe effective practice and feedback events for individuals and units. We need a better understanding of specific learning activities that support specific stages or phases of skill acquisition, transfer, and retention.

Validation of promising laboratory findings. Discussions with academic members of the working groups revealed several promising laboratory findings. For instance, research has shown the need to find a proper balance between the desire to maximize end-of-course performance as quickly and inexpensively as possible and the need to ensure the long-term retention and transfer of the knowledge and skills provided. Research is needed to validate those findings, using militarily relevant tasks and personnel.

Collective performance modeling. The future operating environment will be more complex and difficult, and this will require that the functions of tactical leadership be reconceptualized for collective action rather than individual behavior. Although the unit commander bears ultimate responsibility for mission success, his ability to envision operations and make effective decisions is inextricably linked to the knowledge, expertise, culture, and collaborative behavior of others. Efforts to develop an understanding leadership and to produce unified visualization and decision making would benefit from a model that represents information processing among the multiple members of the team.

Aggregating training data to support automated collective performance assessments. Automating the collection of individual performance data in simulation environments is in progress. For instance, data collected from exercises supported by live, virtual, constructive (LVC) federations of simulations include individual and collective performance. However, how to translate the performance of individuals to the performance of the collective to which they belong is not clear. Also, more must be learned about training conducted individually and training conducted in teams. LVC simulations environments should be used to develop generalized models for aggregating individual data to determine complex collective performance.

How Do We Provide Relevant Knowledge-Based Training Support?

Both the rate and the nature of change will accelerate. Change and unpredictability will become the norm, and traditional reliance on formal training will not suffice. Rather, we will need a variety of instructional/learning technologies (e.g., knowledge management, embedded training, dL, unsupervised learning) and a better knowledge about the differences between initial and refresher training.

What We Know

The Army is capable of training for particular situations. This capability includes general situations (e.g., prepare for a chemical, biological, radiological, or nuclear attack; perform movement to contact; prepare a perimeter defense) and specific situations (e.g., rock drills, mission rehearsals, sand table exercises).

The Army also knows and applies the fundamentals of skill transfer. We know that the key to effective learning and transfer is "relevance." Soldiers' motivations to learn are a function of the perceived relevance between training content and job performance. Relevance is based on perception and is not the same as fidelity. For example, the capability of a simulation to recreate the visual detail (e.g., those related to cultural objects) is relevant only to the extent that it relates to tasks being trained.

What We Don't Know

Although the Army knows how to train for particular situations, some of the details of training execution are not well understood. For instance, we don't know how best to sequence different training experiences for maximum performance effect within constrained resources. We also don't know how best to select training media and venues from among the myriad of choices.

Although the fundamentals of skill transfer are well known, the details are sketchy. For instance, the concept of "relevance" is sound, but reliable methods for measuring relevance and adapting it to training objectives need more development. Likewise, the phenomenon of negative transfer is well understood, but we lack procedures for minimizing negative transfer when jobs, equipment, and procedures change. Specifically, we don't know how to distinguish between negative transfer that matters and is harmful and negative transfer that is less important and easily unlearned.

The key capability for a flexible and individually tailored training system is knowledge management. Although the need for knowledge management is clear, some of the fundamental requirements of the system are murky. For instance, we don't know how to encode data and lessons learned (including content and Soldier-relevant information) into an easily reused format. Further, given appropriately coded data, the automated methods for abstracting principles from these data and applying these data ("reasoning") need further development.

Future Applications

Assuming that some of the future capabilities discussed previously were available, the following example applications could be envisioned:

- *Rapid scenario generation.* Automated and knowledge-enabled systems could be used to configure scenarios rapidly to rehearse the current mission.

- *Personalized dialog-enabled training agents.* Soldiers could interact with personalized systems in natural language to provide tutoring functions, including selection of content, guiding practice, and providing feedback—all made appropriate to the individual's level of expertise. These same capabilities can be easily extended to performance and decision aiding.

- *Acquiring and applying lessons learned.* Knowledge management and techniques for natural language understanding can be developed to facilitate the acquisition and application of lessons learned.

What Research is Needed

To facilitate development of these future applications, the following lines of research need to be pursued:

- *Advanced machine intelligence and knowledge management.* Advanced machine intelligence capabilities should be applied to knowledge management technologies to develop
  - Reusable and computable knowledge. Standardized methods for encoding experience, abstracting, and reusing knowledge are beginning to emerge. To be put into practice, these methods require the creation of large bodies of formal reusable and computable knowledge. Automated methods for generating this extensive database need to be developed further.
  - Reach-back capability/lessons learned. Methods are needed to automate the discovery, understanding, and application of knowledge derived from large corpora of encoded and unencoded text. These methods can be applied to aid the analysis of open sources (e.g., reach-back capabilities) and closed sources (e.g., lessons learned).

- *Training design principles.* Review and meta-analysis of the research literature should be conducted to create a catalog of design principles that "do" and "do not" contribute to durable and flexible learning. Topics should include
  - learning to learn,
  - tutoring applications, and
  - social cohesion and influence.

- *Authoring tools.* Authoring tools that aid nonspecialized users in developing and implementing knowledge-based products (e.g., tactical scenarios) should be developed.

The tools should allow local commanders in theater to create and/or edit scenarios, simulation environments, and other training content easily and rapidly.

- *Social and cultural factors.* Research is needed to determine how best to include social and cultural factors in training programs. These behavioral factors should also be incorporated into analytic simulations (e.g., force models).

- *Dynamic performance-contingent guided learning.* Instructional systems must be able to adapt dynamically to learners' knowledge, skills, and abilities if the efficiencies available from technology are to be realized.

How Do We Develop Low-Cost, Effective Training Tools?

What We Know

One of the ironic but consistent findings in transfer of training is that inexpensive, low-fidelity simulations can provide training that is just as effective as expensive, high-fidelity simulations. Research has found that the effectiveness of training simulations depends more on their relation to task requirements (relevance) than on their ability to recreate physical reality (realism).

Another finding is that domain-specific training tools are the most effective but the least transferable. One emerging approach for increasing the transferability of specific knowledge is to create reusable instructional content. In other words, an instructor can assemble individual knowledge objects required to train within one (specific) domain and then reassemble those same objects (along with others) to train in another (specific) domain. Thus, content reusability is not only a method that reduces the cost of instructional development, but it also provides an approach to improve flexibility. Content reusability requires the application of standards that are starting to emerge for technology-based instruction.

Web-based technology has enabled the development of collaborative learning and knowledge sharing. These new approaches have been demonstrated to be effective and inexpensive. However, the relationship between collaboration technologies and traditional training approaches is unclear.

What We Don't Know

Training investments are subject to the ubiquitous law of diminishing returns (i.e., the increments in effectiveness decrease over increasing investments). At some point, further investment in training technology is not commensurate with the resultant increase in performance. This conceptual point is sometimes identified as the place in which the technology is not at its highest attainable point but is "good enough" to provide usable benefit. Although we understand "good enough" in concept, we do not know how to determine its military and operational value.

We are currently learning how to define and create standardized learning objects; however, we don't yet know how to store, retrieve, and exploit these objects into meaningful programs of instruction.

Advances in social psychology, motivational psychology, and cognitive neuroscience will help us to understand better the human interfaces and the fundamental learning structures and processes. Research is needed to exploit these advances so that we can accelerate training and make it more cost efficient.

Future Applications

Discussion of these future needs and capabilities suggest some possible applications to Army training:

- *Unified collaborative training environment.* Currently, structured training and collaborative learning are perceived as separate activities. A knowledge-enabled environment could be created to unify these disparate fields so that we can leverage each to maximize their strengths and minimizes their weaknesses.

- *Interface designs.* Advances in neurocognition and knowledge management could be used to design human interfaces that aid the nonexpert Soldier in using and modifying training tools.

What Research is Needed

To facilitate development of these future applications, the following lines of research need to be pursued:

- *Integration of learning principles.* To be integrated into training tools, principles of effective learning need to be identified and organized according to domain/application. Learning science will need to continue theoretical and empirical research in this area.

- *Automated acquisition of expertise.* Genuine expertise is a rare commodity. Research is needed to develop methods for providing the nonspecialist's access to this valuable resource. Specifically, automated tools and systems are needed to discover, access, and exploit sources of expertise.

- *Integration of interface design principles.* For truly learner-centric, technology-enabled training tools, research in human-computer interactions should be pursued. Such research would identify principles for developing the optimal interface between the Soldier and the training system.

- *Basic research related to training.* Basic research in the fields of social psychology, motivational psychology, and neuroscience needs to be funded for applications to Army training.

- *Performance benchmarks.* Methods are needed for benchmarking performance. These methods should be independent of training tools and training scenarios. The concept is to derive metrics and standards for evaluating different approaches to training and for predicting readiness and combat effectiveness.

VII. RECOMMENDATIONS

This section summarizes the work completed by the four working groups: Learning Model, Train Soldiers, Develop Leaders, and Future Capabilities. For each working group, this section discusses the principal findings, derives implications of those findings, and provides a possible recommended way ahead for the Army.

Learning Model Working Group

Findings and Implications

The two principal findings from the Learning Model Working Group were to (1) try GEL on a limited basis as an example of a scientifically based instructional strategy and (2) study the applicability of the HPI model for solving Army human performance problems. Assuming that these models were to be adopted, some implementation issues would affect the Army as a whole:

- The training workforce must be brought on board through strategic communications and professional development.
- To align personnel, training, and acquisition functions, fundamental changes must be considered in policy, process, and structure.
- The models must be standardized to prevent piecemeal and inappropriate implementation.
- The focus on performance entails the development of new and improved performance measurement processes and metrics.
- Instead of delaying implementation by waiting for long-term studies and analyses, the program ought to proceed with the 80% solution (based on best practices from other organizations) and adjust through continuous follow-up.

Way Ahead

Realizing that the two changes suggested by this working group require a significant cultural change, a high-priority and dedicated team of experts from multiple disciplines should study lessons learned from the Navy, Coast Guard, and industry. This team should work to devise a plan and then manage the implementation of the scientifically based instructional methodology and the incorporation of the HPI to align personnel, training, and acquisition functions. This team could also oversee a third implementation project—a pilot test to determine the affect of cohort socialization on learning in a blended dL/f2f course. However, this last project probably has fewer Army-wide implications than the other two.

Findings and Implications

The findings from the Train Soldiers Working Group can be summarized by three broad assertions:

1. dL technology can be used to accelerate training, reduce costs and personnel requirements, and improve operational effectiveness without adversely affecting Soldiers or their families.

2. Significant advantages in the acceleration of training, the reduction in costs, and the reduction of personnel requirements can be realized by streamlining Army courses.

3. Through deliberate dL training, the Army will be able to ensure its use and realize the benefits it offers for training effectiveness and efficiency and improvements in operational effectiveness.

Way Ahead

The group's findings pointed to three future actions:

1. *Increase the use of dL technology.* A fundamental prerequisite for increasing the use of dL is to resource, promote, and support up-front investment costs for dL. In addition, R&D efforts are needed to understand and overcome within-Army cultural barriers to dL, identify the incentives and infrastructure for early dL adopters, define learner and instructor training needs for dL, develop further the training strategies and techniques for dL, and determine the cost effectiveness and ROI for dL.

2. *Streamline Army courses.* The way ahead for this set of actions has several different paths. First, cooperative agreements between Army personnel and training organizations must be developed to provide AOT that tailors training objectives to an individual's current and/or imminent duties. Second, standing, routine processes are needed to harmonize and balance TRADOC's long-term institutional responsibilities for training and education with the more immediate needs of the Operating Forces. Such processes are also needed to balance training responsibilities between residential and unit venues. Third, similar standing and routine processes are needed to balance the design and development of performance and decision aids (especially those delivered by dL) with the objectives and approaches of training. Fourth, R&D is needed to advance supporting technologies (e.g., dL "authoring" capabilities) that allow unit-based training materials to be developed or modified rapidly and easily by nonspecialist unit personnel.

3. *Train to use dL*. Several development activities that support the effective use of dL technology by Soldiers and their instructors can be identified. Courses and modules are needed to (a) help Soldiers use dL to assume more responsibility for their own professional development, (b) help instructors successfully integrate dL into their

teaching, and (c) help developers to use more fully the capabilities of dL to improve training effectiveness and efficiency. This courseware should be developed by reviewing and implementing the best practices and lessons learned in developing learning tools (e.g., authoring, learning progress assessment) for dL learners, instructors, and developers. In addition, the best practices of one teacher for one student tutorial instruction should be reviewed and assessed to identify and develop ways to apply these procedures affordably to dL.

Develop Leaders Working Group

Findings and Implications

The findings from the Develop Leaders Working Group identified the following actions for developing better leaders:

- Leverage key intervention points in the Army's education system (WLC, BOLC, CCC, SCP) to influence a leader's ability to effect change in his unit through socialization
- Integrate social networks, communities of practice, and AKO as an electronic supplement to socialization and relationship building
- Document and publicize Army personal leader development experiences
- Add adaptability to doctrine (FM 7-0, *Training the Force*) and to personnel system requirements
- Review available training practices for opportunities to improve adaptability, using as guidelines what we know and what works
- Focus instructor preparation on adaptability principles and practices.

Way Ahead

This working group brought together specialists in leader development from the military, industry, and academia. Participants developed common terms of reference and created a confluence of ideas that were only partially exploited in the time available. For example, discussion about how to measure effectiveness and quality of adaptability in Army leaders was left mostly incomplete. The group provided only an outline about how to foster socialization, adaptive performance, and accelerated leader growth more effectively. A cross-disciplinary group like this one should integrate the themes into more explicit recommendations for Army implementation.

Findings and Implications

The principal directions forecast by the Future Capabilities Working Group were a multidisciplinary research agenda (i.e., psychology, biology, sociology, and computational sciences) with general topic areas including learning and performance, social and cultural behavior, human-machine performance, and predictive models of readiness and performance. This research agenda should validate promising laboratory findings with militarily relevant tasks that incorporate lessons learned from operational environments.

Way Ahead

The group's findings pointed to four future areas:

1. *Learning and performance.* For future Soldiers and leaders, the meanings of "knowledge" and "learning" are changing. Soldiers are in the midst of a growing "information explosion" where the tools they need for job success are expanding. Research should focus on modifying the Army's learning model to ensure that it is comprehensive and effective for increasing knowledge requirements. The model needs to interrelate information from different domains to reflect the "changing nature of knowing." Mastery of facts is inadequate without the ability to access and integrate new information.

2. *Social and cultural behavior*. Research about ways to improve social and cultural skills takes on new importance as joint and combined operations become the norm rather than the exception. Research using modeling and simulation (M&S) that includes distributed systems will help us understand how best to represent social interactions and portray cultural behavior. This research should include how to train for interactions with a full range of cultures, including hostile aliens, neutral populations, coalition partners, and nonmilitary organizations.

3. *Human-machine performance.* Soldiers will increasingly rely on and interact with machines for individual and team performance enhancement. The Soldier, as a system enhanced by computers and new weapon capabilities, will be joined by robots. Research is needed to explore how to optimize the performance of these systems, the human-machine interface, and task sharing for optimal effect.

4. *Predictive models of readiness and performance*. The design of training programs would improve greatly if we could use performance to predict readiness and, ultimately, to predict combat effectiveness. One key research step is to build and test predictive models that link individual and collective performance. Another is to build predictive linkages between performance and combat readiness. The goal is to determine components of actual combat effectiveness. Such predictive models would allow the Army to assess the military value of individual and collective performance enhancements.

REFERENCES

Anderson, J.R. (1990). *The adaptive character of thought*. Hillsdale, NJ: Erlbaum.

Anderson, J.R., and Liebrere, C. (1998). *The atomic components of thought*. Hillsdale, NJ: Erlbaum.

Bjork, R. A. (1994). Memory and metamemory considerations in the training of human beings. In J. Metcalfe and A. Shimamura (Eds.), *Metacognition: Knowing about knowing* (pp. 185–205). Cambridge, MA: MIT Press.

Bjork, R.A. (2007). *How we learn versus how we think we learn: implications for the optimization of army training* [Briefing in Appendix CD]. Hampton, VA: Army Science of Learning Workshop.

Brown, R.B. and Sims, D.A. (May–June 2005). Transforming in peace and war. *Military Review*, 22–26.

Bullis, C., Gerras, S. and Wong, L. (2005). *Agile leader study* [Unpublished Briefing]. U.S. Carlisle Barracks, PA: U.S. Army War College, 2005. [See also, Gehler, C.P. (2005) *Agile leaders, agile institutions: educating adaptive and innovative leaders for today and tomorrow*. Carlisle Barracks, PA: U.S. Army War College.]

Chao, G.T. (2007). *Organizational socialization: Leaders and developmental networks for work adjustment*. [White paper in Appendix CD]. Hampton, VA: Army Science of Learning Workshop.

Clark, R. E. (2004). *Design document for a Guided Experiential Learning course* (Contract No. DAAD 19-99D-0046-0004). Los Angeles, CA: Institute for Creative Technologies.

Clark, R. E. (2007). *Learning model* [White paper in Appendix CD]. Hampton, VA: Army Science of Learning Workshop.

Clark, R.E., and Estes, F. (2002). Turning research into results: A guide to selecting the right performance solutions. Atlanta, GA: CEP Press.

Dorsey, D. (2007) *Adaptability and adaptive performance: current findings and future directions for building adaptive forces.* [White paper in Appendix CD]. Hampton, VA: Army Science of Learning Workshop.

Executive Review of Navy Training (2001). Revolution in training.

Fallesen, J.J. (21 July 2006) *Army leader characteristics for full range operations: comments on FM 6-22, Army leadership.* Fort Leavenworth, KS: Center for Army Leadership.

Headquarters, Department of the Army (2002). *Training the force* (FM 7-0). Washington, DC: Author.

Moran, K. (2007). *Sea warrior and the revolution in training: The right person, right place, right skill, right time, best value.* [Briefing in Appendix CD]. Hampton, VA: Army Science of Learning Workshop.

Pulakos, K.C., Schmitt, N., Dorsey, D.W., Hedge, J.W., and Borman, W.C. (2002). Predicting adaptive performance: Further tests of a model of adaptability. *Human Performance, 15(4),* 299–323.

Sams, M. (2007). *Welcome address: Science of learning workshop* [Address in Appendix CD]. Hampton, VA: Army Science of Learning Workshop.

Scales, R. H. (2006). Clausewitz and World War IV. *Armed Forces Journal, July*, 15–24.

Wallace, W. S. (2006). Victory starts here! Changing TRADOC to meet the needs of the Army. *Military Review*, *May–June*, 59–69.

Wallace, W. S. (2007). TRADOC is architect of the Army. [Briefing in Appendix CD]. Hampton, VA: Army Science of Learning Workshop.