RAND ARROYO CENTER

RESEARCH BRIEF

Microworld Simulations

A New Dimension in Training Army Logistics Management Skills

RAND RESEARCH AREAS
CHILDREN AND ADOLESCENTS
CIVIL JUSTICE
EDUCATION
ENERGY AND ENVIRONMENT
HEALTH AND HEALTH CARE
INTERNATIONAL AFFAIRS
U.S. NATIONAL SECURITY
POPULATION AND AGING
PUBLIC SAFETY
SCIENCE AND TECHNOLOGY
SUBSTANCE ABUSE
TERRORISM AND HOMELAND SECURITY
TRANSPORTATION AND INFRASTRUCTURE

This product is part of the RAND Corporation research brief series. RAND research briefs present policy-oriented summaries of individual published, peer-reviewed documents or of a body of published work.

Corporate Headquarters
1700 Main Street
P.O. Box 2138
Santa Monica, California
90407-2138
Tel 310.393.0411
Fax 310.393.4818

© RAND 2004

www.rand.org

Abstract

RAND Arroyo Center has been exploring ways to improve the training of Army Combat Service Support logistics personnel, focusing on a new strategy that emphasizes the processes at the core of CSS operations. The research has examined the use of microworld models to teach complex management skills and to highlight that teaching with dynamic simulations of specific processes.

Providing effective training to Army personnel is always challenging, but the Army faces some new challenges in training its logistics staff managers in units. As the Army evolves into a "force-projection army," it must be ready to deploy quickly and conduct missions away from the locations where soldiers are stationed and where materiel and services are readily available. The design and management of the Army's Combat Service Support (CSS) large-scale logistics systems are increasingly important.

The skills that are required to manage these systems are difficult to train. Large deployments occur irregularly and thus opportunities for individual staff members in field units to design and manage contingency distribution systems are limited. Furthermore, many of the people who work in high-level logistics management units are in the Army Reserve, and they train and practice their skills part time. Also, reserve units tend to be spread across large geographic areas, which makes it difficult to regularly train complete units at one time. Finally, there is considerable personnel turnover in the reserves, which creates the frequent need to train newcomers. The Army's ongoing revision of its logistics doctrine exacerbates these challenges.

In a series of projects sponsored by the U.S. Army Combined Arms Support Command and by the Chief, U.S. Army Reserve, RAND Arroyo Center examined the Army's logistics training for unit staff and made recommendations for improving it. In *Microworld Simulations for Command and Control Training of Theater Logistics and Support Staffs: A Curriculum Strategy* (Bondanella et al., 1999), the authors recommend a new training strategy that focuses on the processes that are the core of CSS operations. This "process approach" takes an end-to-end view of the entire system and allows those being trained to understand how their role fits into the larger process. It requires changes in the structure, content, and delivery of training. For example:

- Unit training should be structured in a series of short training sessions each year with each session building on the previous one, and one large session at year-end. However, modules should be readily available for "training on demand" as required by the units.
- The content of the training should be broader, teaching the skills needed to efficiently manage a dynamic system.
- Training should be delivered via computer-based simulations called "microworld models," based on research concerning such models in the academic community.[1]

Structuring Logistics Training

During the early stages of this research, RAND Arroyo Center researchers found that there were few opportunities to train higher-level unit staffs as staff entities. For example, some units could only participate in a simulation-supported, large-scale

[1] The term "microworld" appears to have originated at the MIT Artificial Intelligence Laboratory in the early 1970s (Lawler, 1987) and was later popularized by Seymour Papert (1980). Although a microworld can be built using any enabler, Papert used the term in the context of a "computer-based learning environment for children, in which they could program the environment, see how it responded, and draw out their own understanding of the principles of mathematical relationships." See also Senge et al. (1994), p. 531.

exercise once every two years. That situation was aggravated by high turnover within the staff when people moved to other positions. Furthermore, staff officers in units did not have the time and, in many cases, the resources to structure a curriculum that kept pace with new concepts and business rules emerging from the Force XXI program. The Army's formal training establishment was focused more on residence training in Army schools rather than on support to field unit training and exercises.

RAND researchers believe that logistics training for unit staffs should be structured so that it focuses on the overall goals of the logistics units and provides more appropriate, integrated training opportunities. A series of small focused seminar war games early in the annual training cycle might address early-entry aspects of building a logistics infrastructure for an operation. The sessions might be designed so that they are self-contained in four-hour blocks. These time periods would allow focus on a particular topic in a year-long curriculum while corresponding to the time available to soldiers in Army Reserve field units because reservists get paid in four-hour increments. Subsequent sessions and exercises should then focus on each phase of a contingency—the build-up of forces and infrastructure, sustainment management, and redeployment. The learning goals from each exercise should lead into the goals for the next one, with a large, culminating event once each year. This structure of training events through the training year should allow more learning to occur despite existing constraints on time and resources.

Broadening the Content of Logistics Unit Training

Apart from the structure of training, RAND Arroyo Center researchers found that training exercises were focused too narrowly, concentrating on sustaining an operation after the theater has matured and ignoring the critical training that CSS staffs need in the early stages of building a theater infrastructure. The content of training, i.e., the knowledge and skills that are the target of the training exercise, should be shifted from the current emphasis on the present to proactive management of the future. This is a major shift in training emphasis, from trying to account for current assets and chase down missing materiel, to managing a dynamic system and looking ahead to minimize bottlenecks and delays. Such management skills are reportedly rarely practiced in current exercises, partially because the exercises have a limited ability to simulate the length of time required for large-scale logistics plans to unfold.

In *The Use of Microworld Simulations to Train Theater Level CSS Staffs: Training Development Considerations* (Ettedgui et al., 2000), RAND Arroyo Center researchers proposed the use of a "skills matrix" to help plan the content of training (illustrated in the table to the right). The matrix reflects a set of training objectives that were developed by RAND and expanded in a training partnership between RAND and the 377th Theater Support Command. The skills listed in the matrix fall under two broad categories: basic system knowledge, as described in the first two columns on the table, and measuring, diagnosing, and managing complex systems, as described in the last three columns on the table.

The matrix provides a comprehensive framework for evaluating staff training needs based on their mastery of skills. For example, if staffs have mastered the basic skill "Identify main supply routes," then the next step should be to teach the skill in the next column, "Develop/implement transportation networks." Likewise, it would be preferable to teach the skill in the last column at the top, "Take appropriate action to work around choke points," after staffs have mastered the more basic skills.

The Process Approach and Microworlds Show Promise

A third component of RAND Arroyo Center's recommended approach to training is to use microworld models to teach complex management skills and to highlight that teaching with dynamic simulations of specific processes. In fact, many commercial model applications of the type Arroyo proposes are labeled as "process models." A microworld is a computer-based learning tool that enables an individual to interact with a specific environment much in the way that a flight simulator enables a pilot to practice a wide range of aerial maneuvers. Microworld models can be built from commercial, off-the-shelf software packages, thus allowing Army training developers to focus on the models themselves, not the authoring of underlying code. The commercial providers offer technical support as needed.

Proponents of microworlds assert that these models can simulate dynamic processes, such as a theater-level management distribution system, enable exploratory learning (i.e., discovering what kinds of problems will crop up), and train on-the-job skills. They can teach managers about the processes for which they are responsible, and help them understand how certain variables in their organizations relate to certain outcomes. They can be used to train new members in several different locations simultaneously and without waiting for infrequently conducted large-scale exercises. Microworlds are far less expensive and more flexible than large-scale simulations that run on mainframe computers. The Army's existing large-scale simulations traditionally have focused on the war fighter rather than support staffs.

When Arroyo undertook this research, there was little empirical data on the effectiveness of using microworlds to teach complex management skills. Consequently, Arroyo developed a quasi-experimental procedure and tested it on a few different occasions in prototype sessions with support commands (the 310th Theater Army Area Command and 311th Corps Support Command) in 1997 and 1998. The findings from these sessions were published in *Exploring the Use of Microworld Models to Train Army Logistics Management Skills* (Levy et al., 2001). The Chief, Army Reserve (CAR) asked Arroyo to demonstrate its ideas in actual training sessions with another unit to determine if they could be feasibly implemented. The CAR selected the 377th Theater Support Command (TSC), a newly formed organization resulting from the Army's Force XXI program.

Arroyo researchers demonstrated that the process approach and the use of microworlds offer benefits for training unit staff in complex logistics management skills. Three-hour sessions were organized around a microworld model that simulates a simplified version of a distribution management process. Arroyo devised and administered a pre-test and post-test that provided statistical results concerning

Skills Matrix

Basic System Knowledge		Measuring/Diagnosing, Managing Complex Systems		
Basic/Enabling Knowledge/Skills	System Understanding	Building/Expanding Operations	Executing Normal Operations of Systems	Handling Exceptions/Crises
Identify main supply routes	Develop/implement transportation networks	Design distribution network	Monitor status of distribution network and manage its flow	Take appropriate actions to work around choke-points
Determine stockage levels	Understand alternative modes of distribution	Anticipate logistical requirements	Manage upstream supply/ materiel flows	Prioritize requirements, reallocate resources to meet objectives
Understand modal resources	Understand host nation support, integration	Implement distribution network	Manage and track asset status	Integrate available assets to meet distribution needs
Filter/utilize logistics information	Understand automation information systems	Develop system that continually reviews relevant information	Keep system in equilibrium	Use alternative information-gathering techniques
Understand evolving logistics techniques, doctrine, and procedures	Understand just-in-time resource management	Incorporate state-of-the-art processes	Monitor relationships with sources of supply	Establish procedures to minimize crisis impact

student learning. Researchers found that, on average, participants were able to identify more problematic trends in data after training than they were before training. Improvements in their ability to identify the effects of the trends were smaller but still significant. The subjective measures also showed positive effects of the training. The soldiers who participated expressed a clear preference for the Arroyo approach; it was more in line with their needs than previous training and taught a better understanding of system dynamics. Specifically, they reported increases in their understanding of how to measure a theater distribution system, how to evaluate alternative distribution policies, how to estimate the effects of policies over time and on other organizations, and how to manage a general supply distribution network. This experimental training was intended for mid-level CSS staff in their field units who have some perspective on, but not sole responsibility for, theater-level distribution management systems. Although only reservists were included in the experiment, the researchers believe that the results are generalizable to other Army personnel, as well.

RAND Arroyo Center's evaluation provided quantitative and qualitative measures that confirmed the value of the process approach and suggests that the use of microworlds could offer benefits if adopted by the Army. However, the research team believes that a different sort of assessment technique would be preferable for future training. Arroyo researchers also provide further recommendations to modify the structure of training. These ideas are discussed below and in *Designing Assessments of Microworld Training for Combat Service Support Staff* (Straus et al., 2003).

Modifying Training Structure to Accommodate a Microworld Approach

The use of microworld training in the Arroyo experiment led to significant improvement in participants' ability to identify trends in data and analyze the effects of those trends; however, the absolute level of knowledge was relatively low. A likely explanation for this result is that the material was challenging and the amount of time available to conduct training did not allow for sufficient individual practice with the simulation. Individual exploration of alternative policies is one of the theoretical underpinnings of microworld training. In future training, participants should have opportunities for individual hands-on practice with microworld models. However, because trainees can also benefit from collaboration during training (see Liang, Moreland, and Argote, 1995; Lim, Ward, and Benbasat, 1997; Olivera and Straus, 2000), Arroyo recommends a combination of group and individual practice.

Assessing Training Effectiveness

RAND Arroyo Center researchers believe that the original knowledge assessment, which consisted largely of open-ended knowledge questions, did not fully capture dimensions of student learning. In addition, open-ended questions require substantial training of test evaluators to ensure reliability and validity in scoring, a challenge that is exacerbated by frequent personnel turnover. A more objective method will enhance training efficiency, which is a key quality assurance goal of Army training (as articulated in the Army document TRADOC PAM 350-70-4). Providing a structured, objective method could be particularly beneficial to units, which traditionally rely on after-action reviews, or qualitative discussions of lessons learned during a particular event. In Straus et al. (2003), the authors identify a comprehensive set of measures to better assess learning and pinpoint areas for improvement in training content and processes. Recommendations include using a multidimensional, objective approach to measuring learning outcomes that includes cognitive, skill-based, and affective measures at multiple points in time (see Kraiger, Ford, and Salas, 1993).

Looking Ahead

Computer-based microworld models appear to offer a reasonable solution to the challenges faced by the Army in teaching complex logistics management skills. If the promise of the models holds true, they will play an important part in training a wide variety of

management skills in both military and commercial settings (see Senge et al., 1994).

The Army might pursue a number of directions to support their use. For example, it could develop reusable libraries of scenarios to be accessed via networks. In addition, to enhance collaboration among trainees in different locations and in sister organizations, the microworld curricula might be made available via the World Wide Web. In fact, the developers of the tools to build microworlds are now developing tools that allow the microworlds to be used across several distributed locations. This capability is growing in the commercial Internet market with interactive games and will be enhanced with the newly emerging peer-to-peer computing (P2P) applications being developed. Although there are no industrywide P2P standards yet, the CSS training research team is devising a set of recommendations concerning how the Army might position itself in the near term to leverage P2P strategies and future techniques.

RAND Arroyo Center developed a prototype web site that illustrates how training developers could provide resources (including mentors, actual curricula, and simulations in addition to doctrinal publications and other information) to accommodate the need for "training on demand." A sample of site contents can be viewed at www.rand.org/ard/CSSTrainingPrototype.

This research was conducted at the same time that significant change is taking place and new organizations are being formed as part of the Army's transformation. The Army transformation is spawning more rapid change, and hence requires more responsive training. Further, the institutional training base of resident schools may not be able to keep pace with demands to retrain soldiers in existing field units as new concepts, organizations, business practices, and equipment emerge. Consequently, commanders and soldiers would benefit if the Army were to adopt the proposed microworld training approach, which may include some reallocation of training development resources to support field unit training. ■

References

Bondanella, J.R., Lewis, M.W., Steinberg, P., Park, G.S., Levy, D.G., Ettedgui, E., Oaks, D.M., Sollinger, J.M., Winkler, J.D., Halliday, J.M., and Way-Smith, S. (1999). *Microworld Simulations for Command and Control Training of Theater Logistics and Support Staffs: A Curriculum Strategy*, Santa Monica, CA: RAND Corporation, MR-929-A.

Ettedgui, E., Oaks, D.M., and Bondanella, J.R. (1999). *The Use of Microworld Simulations to Train Theater Level CSS Staffs: Training Development Considerations*, Santa Monica, CA: RAND Corporation, DB-265-A.

Kraiger, K., Ford, J.K., and Salas, E. (1993). "Application of Cognitive, Skill-Based, and Affective Theories of Learning Outcomes to New Methods of Training Evaluation," *Journal of Applied Psychology*, 78, 311–328.

Lawler, R.W. (1987). "Learning Environments: Now, Then and Someday," in R.W. Lawler and M. Yazdani (eds.), *Artificial Intelligence and Education, Volume I: Learning Environments and Tutoring Systems*. Norwood, NJ: Ablex.

Liang-Rulke, D., Moreland, R., and Argote, L. (1995). "Group Versus Individual Training and Group Performance: The Mediating Effects of Transactive Memory," *Personality and Social Psychology Bulletin*, 21, 384–393.

Levy, D.G., Lewis, M.W., Bondanella, J.R., Baisden, M., and Ettedgui, E. (2001). *Exploring the Use of Microworld Models to Train Army Logistics Management Skills*, Santa Monica, CA: RAND Corporation, MR-1305-A.

Lim, K.H., Ward, L.W., and Benbasat, I. (1997). "An Empirical Study of Mental Models and Computer System Learning," *Information Systems Research*, 8(3), 254–272.

Papert, S. (1980). *Mindstorms: Children, Computers, and Powerful Ideas*, New York: Basic Books.

Senge, P.M., Kleiner, A., Roberts, C., Ross, R.B., and Smith, B.J. (1994). *The Fifth Discipline Fieldbook: Strategies and Tools for Building a Learning Organization*, New York: Doubleday.

Straus, S.G., and Olivera, F. (2000). "Knowledge Acquisition in Virtual Teams," in M.A. Neale, E.A. Mannix, and T.L. Griffith (eds.), *Research on Managing Groups and Teams: Volume 3. Technology*, Greenwich, CT: JAI Press.

Straus, S.G., Williams, V.L., Bondanella, J., Oaks, D., and Ettedgui, E. (2003). *Designing Assessments of Microworld Training for Combat Service Support Staff*, Santa Monica, CA: RAND Corporation, MR-1759-A.

This research brief describes work done for RAND Arroyo Center documented in *Designing Assessments of Microworld Training for Combat Service Support Staff*, by Susan Straus, Valerie Williams, John R. Bondanella, David Oaks, Emile Ettedgui, MR-1759-A, 2003, 50 pp., $18.00, ISBN: 0-8330-3448-0, available at http://www.rand.org/publications/MR/MR1759/. Also available from RAND Distribution Services (phone: 310-451-7002; toll free 877-584-8642; or email: order@rand.org). That report and this brief build on the concepts in several other RAND Arroyo Center reports that are cited in the text and listed in the references. RAND Arroyo Center URL: http://www.rand.org/organization/ard/. The RAND Corporation is a nonprofit research organization providing objective analysis and effective solutions that address the challenges facing the public and private sectors around the world. RAND's publications do not necessarily reflect the opinions of its research clients and sponsors. **RAND**® is a registered trademark.

RAND Offices Santa Monica • Washington • Pittsburgh • New York • Doha • Leiden • Berlin • Cambridge

RB-3037-A (2004)