Learning Methodology Reference Document

Prepared for

NAVSEA Performance Monitoring, Training and Assessment Program Office (PMS430)

Prepared By

James Brewer

Michael Burke

Dr. Linda Fenty

Dan Patton

Jerry Post

Dr. Henry Simpson

March 1999
Washington DC USA

A *Thank You* is extended to all the people who have contributed to the development of this document. Numerous individuals representing themselves or larger groups have made valuable contributions both in the conceptual ideas that led to the establishment of the Learning Methodology Working Group and to the content of the document itself.

Table of Contents

FOREWORD: Why Learning Methodology in a Technical Program?

There is no denying that technology has altered how we live, work, and play throughout the world. The advent of computers and networking systems has opened new thresholds for research and development in not only how we move information from one place to another but also in how we learn and train. But regardless of how fast and complex our current technical systems become, they still do not surpass the complexity and individualism of the human mind. A technical system that does not enhance the abilities of the humans who operate it is only that--a machine without a purpose. And humans who do not leverage the capabilities of the technologies available to them are limiting their abilities to achieve and learn. The ideal is to assure that the psychology concepts of learning are incorporated into the architecture and programming of systems so that maximum capability may be achieved *and* that the appropriate technologies are accessible and available to support these concepts. In no other environment is this more crucial than in the military.

With the ever increasing complexity of weapon systems to be learned and operated, changes in warfighting doctrine, reduced availability of live assets and terrain for training, and fewer personnel available for more deployments, technical models and simulations are becoming among the most critical force multipliers within our current defense programs. It is not enough to budget for and build the technologies; to ensure that future systems provide the most effective learning environment available, we must include up-front design that supports a validated learning methodology.

Just as technologies need people to be useful, educational psychology needs applications and continued research to identify how we learn and transfer new knowledge and skills to tasks at hand. A learning methodology is a systematic approach to learning that can be applied to the development of a technical system to enhance and expedite learning. Consideration needs to be given to both behavioral and cognitive aspects of learning. The behavioral aspects of an individual can be *observed*. As behaviors have been studied and identified, we have learned they can affect **how** a person learns as well as **how much** he can learn and **transfer** to the task at hand. Much research has been conducted on identifying and treating behavioral learning problems, and educators and trainers have made great strides in prevention and intervention of behavioral obstacles to learning.

Cognitive psychologists focus on the mind and mental processes, *inferring* that activities occur in brain since we cannot observe the brain’s interactions. We can, however, report the results of the brain’s activities. Cognitive psychologists study mental functioning through the scientific method--solving problems and through combining thinking and data collection. So little is currently known about the human brain that cognitive psychologists base their ideas of the probability of what is going on inside the brain on **models**. A model is a pattern that we understand which seems to function with similarities to the object we are trying to understand.

One type of mental model is borrowed from the computer, because the computer is able to accomplish many of the tasks ascribed to cognitive functioning. The computer and the brain follow a similar process: accepting incoming information, storage of that data, and then applying the stored information at a later date to solve problems. As the brain stores thousands of bits of information, it turns into a search engine as problems need to be solved; it retrieves stored knowledge, and applies that information in order to correct the situation. The more problems to be solved at once, the more complex the brain functioning; it must prioritize, conduct multiple parallel searches for data, then instruct the body on how to respond. In a team-training environment, each member of the team is running parallel processes in his or her brain. The difference is that each individual is uniquely "wired," and each brain is functioning based on its own behavioral conditioning and style of cognitive processing. The goal of training is to get them all to all work as collectively as possible in assimilating and applying information to the perceived problem.

But comparing the brain function to the computer is too simplistic; a model is an analogy and not a replication to the thing to be studied. Because the mind and the computer are two different things, though they have strong similarities, the mind must ultimately be looked at against other models and continuously studied in its own uniqueness--in that the mind functions beyond information processing through emotional and sensory stimuli. It is the responses to other stimuli that cause diverse levels of learning among individuals. Whereas computers rely on people to construct, activate and deactivate them, people carry unique and individualized patterns of behavior and cognition that affect how they absorb and process information; the computer is a **tool** for learning.

A Learning Methodology applied to the development of a technical system tries to diminish the impact of diverse cognitive and behavioral learning styles by setting a systematic approach to learning, whether focusing on individual or team training. The goal for the learning methodology personnel is to provide the developers with the best *learning knowledge* available so that they in turn can provide the end users with the best *learning tools* that can be built. Learning Methodology accomplishes this by ensuring the development of a robust learning environment. An environment where training activities reflect the perspectives of three critical contributors: the developers of the tools (programmers), the subject matter experts of the content knowledge to be learned (the users), and those who have the most scientific understanding of how people learn (LM personnel). To be successful, it must truly be a team effort, with LM personnel operating as critical members of the collective effort on equal footing with traditional development teams. This dynamic process is best served by providing continuous LM support and guidance *throughout* the requirements, design and build process, rather than *after the fact*.

It is this partnership that will ensure the blending of the best minds in technology, content subject matter, and learning psychology in the building of complex technical training systems. The goal is to provide a system that supports the end users in effective development of the identified critical team core competencies. This manual is intended as a support tool for the individuals who will in some way touch and guide the development of military technical training systems. The focus of Learning Methodology personnel is to provide information to developers and to assist developers by providing a process--a systematic approach to learning--to be embedded within technical training programs. This will help the programmers and developers achieve the ultimate objective: effective **training**. Learning methodology specialists will be able to design the process that will help formulate the training objectives, provide the learning format for the development of the training exercises, and provide the measures of effectiveness for determining the success of the training.

This manual provides a layman's perspective of on Learning Methodology and reflects the team's collective view on the subject. It is intended for use as a reference rather than a “how-to manual.” It provides a continuity of thought from theoretical concepts to methodology implementation. Points of contact are provided for those who wish to obtain more information. The authors’ intent is to provide support both within the government domain and across into the domains of education and business. We welcome ideas, criticisms, and questions--for it is through spirited dialogue that we as technical community learn and create the future.

1. Purpose

This Learning Methodology Reference Document explores the application of Learning Methodology to the design; development and fielding of a simulation based training system. The primary purpose of this document is to provide an in depth explanation of what Learning Methodology is; why it is important to the design and development of technical training systems; and why the systematic process of the Learning Methodology is critical in establishing an effective learning environment. Over a system's life cycle, Learning Methodology can provide valuable guidance in setting requirements, defining design, generating documentation, and testing capabilities and follow-on deployment.

2. Introduction and Background

Learning Methodology has evolved out of a need to improve the military training delivery systems. A paradigm shift has taken place in the battle space faced by our military forces. Over the last thirty years there has been an ever-changing environment of added complexity and ambiguity. The information age has entered the battle space. Initial approaches were centered on using advanced modeling and simulation technology to improve the legacy training processes. The anticipated improvements did not take place; it became evident that a radical change was required to address the situation. As part of the Navy's Tactical Training Strategy (TTS), movement was initiated toward shifting from a training to a learning focus on future systems. The Battle Force Tactical Training system was the first Navy fielded system to make team learning a fundamental system requirement. The models and processes initiated in BFTT were used as the foundations for the cross service Learning Methodology process documented under the Joint Simulation System (JSIMS). The second generation BFTT is integrating the Learning Methodology as part of its development and deployment strategy. The technology and innovation revolution, an outgrowth of the Information Age, has been one of the primary enablers for the advancement of learning systems through the ability to create virtual battle space through interactive models and simulations. Equally important in enabling these advancements have been the research discoveries in the area of cognitive processes.

The JSIMS Learning Methodology Working Group (LMWG) was established in January of 1998, consisting of user representatives and subject matter experts in the implementation of LM. Part of the working group's mission is to ensure that the established precepts of LM are reflected in the processes of technical systems development, from requirement interpretation through system delivery. Toward this end, the members of the LMWG participate in the activities of various Integrated Product Teams (IPTs) and working groups within the program development and implementation. By attending meetings, participating in product peer reviews, and providing LM briefings and white papers to the JSIMS Enterprise members, the LMWG continuously communicates LM related requirements to ensure they are reflected in the efforts of the JSIMS developers. The JSIMS LMWG is continuing its efforts. A second group splintered from the JSIMS LMWG to provide support for the BFTT reengineering process. The LM model is being used to ensure that from software design, to scenario development, through training the trainer, attention to learning issues is a priority consideration. BFTT is in the process of forming a Learning Methodology Working Group as part of its IPT Structure.

This Reference Document is intended to provide a foundation for a communication process by fostering a common understanding of LM and its application to simulation based training systems such as BFTT. The primary purpose of large-scale technical delivery systems is to deliver training to the military services and joint forces. Therefore, the central measure of the success of these systems is their effectiveness in providing effective learning environments that results in measured improvement of the user team's core competencies. A methodology does exist which can form the basis of such a strategy. This methodology, referred to as Learning Methodology (LM), can be viewed as the synthesis of recent research results, as well as practical experience, into a model of the learning process that can be applied directly to the military training environment.

Learning methodology is based upon accepted theories as to how people learn. Over the years, diverse learning theories have been examined, evaluated, demonstrated, and/or applied in a variety of operational and laboratory settings connected with military training. There are differences among the basic theories, and there are many variants of those theories, which focus on different aspects of the learning process. However, the more widely accepted theories do share important common elements; these common elements have given rise to a shared vision of LM across the military services. Three basic theories of learning are discussed in Section 3. Section 4 summarizes key required elements for an effective learning environment, as expressed by the learning theories. Section 5 describes a conceptual model of the learning environment, which is based on accepted learning theories and forms the basis of the shared vision of LM. Section 6 represents the LM vision as a step-by-step process, applied to simulation-based training in a military environment. This LM process model represents a common view of learning that was developed during collaborations among military service and joint representatives. The process, its steps, and the relationships among those steps, form the basis for expressing LM related requirements for a simulation based training system. Those requirements are then summarized in Section 7. Section 8 discusses evaluation requirements and methods.

3. Learning Theories

Presented herein is a brief overview of some of the basic theories on the human learning processes. It should be emphasized that this is not an exhaustive or academic treatment of the subject, but instead the intent is to provide general background as a context for the LM discussions that follow.

A discussion of learning theories is complicated by the existence of many different models of how people learn. Multiple theories continue to evolve with each addition to the knowledge base in the field of learning; currently there is no single theory that has the unanimous support of the scientific community. Moreover, not every person learns the same way in a given situation, nor does a given person learn the same way in every situation. Thus, for the foreseeable future, there will undoubtedly be numerous competing theories on learning, as well as numerous variants of those theories to cover specific types of individuals and learning situations.

Notwithstanding the diversity of learning theories and associated models of the learning process, there are some important concepts that most accepted models have in common. Three basic models are discussed herein to illustrate this commonality as well as some of the differences. These three models are the **behavioralist** approach, the **cognitivist** approach, and the **constructivist** approach. An incidental reason for building the discussion around these particular theories is that they also provide a chronological perspective on the development of learning theories. The behavioralist approach is the oldest of the three, while the constructivist approach is a newly emerging theory.

3.1 Behavioralist Approach

The main tenet of the behavioralist approach is that environmental factors shape a person's behavior. This approach is concerned with changes in an individual's behavior that occur as a result of learning. Therefore, the behavioralist focuses primarily on the development of skills and abilities, as opposed to knowledge.

Early behavioralists identified two types of conditioning, referred to as ***respondent*** and ***operant*** conditioning, which can affect an individual's behavioral response. Respondent conditioning is a process whereby a subject is conditioned to respond to a certain stimulus from the environment. A well-known example of this process is Pavlov's dog, which was trained to salivate when a bell was rung. This training was accomplished by repeatedly ringing a bell just prior to the dog's receiving food.

Operant conditioning is a process whereby the subject's behaviors work on the environment, and feedback is used to reinforce desirable behaviors. Such feedback may be artificial, such as a reward, or it may be a direct result of the subject's behavior, such as the acceleration of an automobile when the accelerator pedal is pressed. As in the case of respondent conditioning, this training is the result of repeatedly providing the reinforcing feedback when the desired response is elicited. It is important that the time lag between the operant response and the feedback be relatively short, so that the individual will correctly pair the behavior with the feedback. This requirement is known as temporal pairing. It should also be noted that feedback might be either positive or negative, depending upon whether the goal is to reinforce or extinguish a particular behavior.

The behavioralist approach has been shown to work for relatively simple skills, but it is not effective when more complex tasks need to be learned. This approach is particularly ineffective when there is a strong cognitive component involved (such as decision making), or when temporal pairing is not feasible.

3.2 Cognitivist Approach

Cognitive theorists are concerned with the changes in an individual's knowledge that result from experience with a stimulus environment. The cognitive approach is based upon the concept of *schemata*, or **mental models,** by which individuals organize their perceived environment.

During learning, these schematic structures change by the processes of specialization and generalization. Specialization involves the integration of new information and experiences into existing schemata. Generalization is the process of modifying existing schemata or of creating new ones. For these processes to work in a training environment, it is necessary to provide multiple opportunities for the individual to make changes and additions to existing models based on experience with the environment.

Mental models exist in long-term memory. Therefore, in order for training to be effective, learning must transfer from short-term memory to long-term memory. Different theories have arisen as to the means by which this transfer occurs. What is important to realize is that an effective learning environment must facilitate this transfer. An individual's mere recollection of a training event, even in minute detail, does not by itself assure that learning has taken place, because this recollection may involve only short-term memory. **A training program must incorporate multiple exposures – and the *right kind*s of exposures – to the environment and to feedback from it, in order for this transfer to take place.**

According to the cognitive approach, in order to ensure that changes in knowledge occur, the learning must be "meaningful". That is, there must be perceived consequences for integrating new knowledge or for failing to do so.

3.3 Constructivist Approach

A more recent development is the constructivist approach, based on the belief that learning is a self-assembly process. Constructivists suggest that individuals "construct" their understanding of a topic area through two processes: **conflict resolution** and **reflection**. Within the constructivist framework, discovery learning (i.e., free play) is preferred over formally structured training. Discovery learning requires the trainee to determine the best way of learning; learning is not externally determined or controlled. The responsibility of the instructor is to structure the learning environment to ensure that there are sufficient opportunities to discover instances of the desired learning objective.

It is believed that discovery learning increases a trainee's motivation to learn and produces richer knowledge stores. However, because complex behaviors can be selected and orchestrated by the trainee, it is possible that the trainee's own goals may deviate from those of the training exercise itself. The result is the potential for loss of control over the exercise on the part of the instructor. An additional problem associated with the constructivist approach is that it can lead to idiosyncratic learning, for two reasons. First, the course and progress of a training session will be determined by what the trainee already knows. Second, only that knowledge which is personally meaningful to the trainee will be integrated into long-term memory stores. These potential drawbacks have led to the suggestion that discovery learning may not be appropriate for **novices** within a domain**. However, as the individual moves towards becoming an expert, discovery learning may foster the development of a richer representation of the problem space.** In this regard, it should be noted that modern technological advances, such as interactive and multi-media computers, laser discs, and the WorldWide Web, can provide trainees with the tools to support discovery learning when it is appropriate.

3.4 Types of Learning within a Learning Organization

Within what is identified by Peter Senge and Michael Marquardt as a "learning organization" several types of learning are practiced:

- *Adaptive, anticipatory, and generative learning*:
  ---adaptive learning is learning from experience and reflection: action—outcome—results data—reflection; can be single- or double-loop learning. Single-loop focuses on gaining information for stabilizing and maintaining existing systems with the emphasis on error detection and correction. Double-loop, a more in-depth process, involves questioning the system itself for the root cause of the errors OR successes.
  ---anticipatory learning is the process of gaining knowledge by envisioning and expecting the future
  ---generative learning is created from reflection, analysis, or creativity.
- *Deutero learning* is technically "learning about learning." It occurs when the organization learns from critical reflection on taken-for-granted assumptions. This type of reflection provides an organization the opportunity to discover what they do (or have done) to either facilitate or hinder learning, to invent new strategies to advance learning with the goal of affecting change in the organizational learning practice.
- *Action learning/action reflection learning* involves reflecting on real problems using the following formula: ***L*(learning) = *P* (existing or programmed knowledge) + *Q*(questioning insight).** As the invention of Reginald Revans, action learning provides a well-tested method of accelerating learning. When used as a systematic process, organizational learning increases so that it can more effectively deal with change and so that its people can learn better and more effectively handle difficult situations. Action learning is used to examine a complex/difficult task, to move people to act to change it, and to return the results to the organization for review and learning; people devote quality time and energy as needed to learn how to learn and think critically. As a result the individuals involved in action learning build the skills to meet team and organizational needs. Some proven principles of adult learning are practiced in action learning participation:
  1. Reflection upon participation in an experience increases learning
  2. If too much reliance is on "expert opinion/information" individuals do not seek own/new solutions
  3. We learn critically when able to question assumptions that drive an action
  4. Accurate feedback from others and results of problem-solving actions increase learning
  5. Working on unfamiliar problems in unfamiliar settings provides greatest challenges; potential and high probability are greatest for learning.
  6. Mixed groups, nonhierarchical, often are better able to gain new perspectives
  7. Action learning is most effective when learners are examining the organizational system as a whole.

From Michael Marquardt, in Building the Learning Organization, comes an identification of specific characteristics for "new learning" that are applicable to what needs to be done to establish an effective learning environment within the military:

1. Learning is performance-based, tied to objectives.

2. Importance is placed on learning processes (learning how to learn) as much, if not more, than on the content.
3. As important as coming up with the correct "answers" is the ability to define the learning needs.
4. Across the organization opportunities are created to develop knowledge, skills, and attitudes.
5. In part, learning is a product of the activity, context, and culture in which it is developed and used.
6. People are more willing and able to learn that which they have helped create.
7. Critical survival skill: the ability to know what one needs to know, and to learn on one's own.
8. Continuous learning is essential for survival and success.
9. Learning can be accelerated if facilitators help people think critically.
10. Learning should both accommodate and challenge different learning style preferences.
11. Learning is part of work—part of everyone's job description.
12. Learning involves a cyclical, iterative process of planning, implementing, and reflecting on action. (p. 32)

Another type of learning that is becoming more and more prevalent is that of *action learning*— a basic ingredient of a learning organization. The primary objective of this type of learning is to induce new thinking by conscious consideration of group content, called "an action learning set." The model is centered on the concept that *setting* (or environment) and *problems* to be considered are an important link to group decisions and the depth of the learning experience. These settings and problems can be categorized as either familiar or unfamiliar, but team learning reaches fullest potential when both setting and problem are unfamiliar.

4. Key Elements Derived from Learning Theories

The accepted theories on learning are applicable to the full spectrum of the learning process, with some elements of each theory pertaining specifically to the development of simulation based training systems. Accordingly, this section summarizes those elements of an effective learning environment, as expressed in the theoretical work, that should be considered in the design and operation of a simulation based training system. For the most part, the elements described herein are taken directly from the theoretical discussions and, if appropriate, re-labeled to relate them to training systems.

The key elements are as follows:

- *Meaningful interaction between the training audience and a contextual environment*
- *Repetition of training events*
- *Variation of exercise conditions in successive training events*
- *Exercise conditions pertinent to learning objectives*
- *Non intrusive data collection of validated performance metrics on team outcomes and processes*
- *Exercise conditions adjusted for existing skills of the training audience*
- *Meaningful exercise conditions*

- *Timely and relevant feedback to the training audience*
- *After Action Review that includes team reflection supported by facilitated, open dialogue.*

These elements may be thought of as **required characteristics** of an **effective learning environment**. They are not binary characteristics; each is met to one degree or another by a given situation. However, the degree to which these characteristics are present will influence the overall effectiveness of the learning environment.

4.1 Efficiency versus Effectiveness

The elements listed above are explicit requirements of an effective learning environment. Efficiency is an implicit requirement that supports all of the listed elements. Clearly, the trainer/facilitator must be actively involved in each of those elements. A primary purpose of an automated training system such as BFTT is to support the trainer/ facilitator in ensuring those elements are present. The effectiveness of the learning environment will be determined in large measure by the efficiency that the training system imparts to the process. For example, the value of timely feedback to the training audience illustrates the close coupling of the effectiveness and the efficiency of the training system. If the process for creating and delivering after action review (AAR) products is so efficient as to preclude significant delays in providing feedback, then the learning environment will be more effective; i.e., a gain in efficiency leads to a gain in effectiveness.

Each of the key elements is described below and is related to the learning theories introduced previously.

4.2 Meaningful interaction between the training audience and the environment

For learning to occur there must be a relationship between the actions of the training audience and the situation in the environment. The term “interaction” refers to the fact that this is a two-way relationship. The training audience must influence the situation through its behaviors, and there must be feedback from the environment reflecting that influence. Providing this interaction is the core function of a simulation based training system. The term “meaningful” implies that the environment’s reactions to the actions of the training audience must be realistic and related to the learning objectives. For example, if a training program is to instill a particular desired competency, the training audience must be able to discern and reflect upon the tangible effects of acquiring or not acquiring that competency.

4.3 Repetition of training events

The need for *repetition* is fundamental to the learning process. The effective transfer of knowledge to long-term memory depends upon repetition. For learning to occur there must be sufficient opportunities for the training audience to experience the relationship between its actions and the situation’s outcome. Implicit in this requirement is the need for successive training sessions with multiple events that allow the team to demonstrate what they know to be appropriately timed. The interval between sessions must be long enough to permit reflection on actions, but not so long as to de-couple the events. One of the advantages of a simulation-based exercise is the ability to repeat events.

4.4 Variation of exercise conditions in successive training events

As noted above, effective learning is the result of sequences of training sessions, rather than independent situations. However, the repetition of identical events is not generally an effective strategy, for a number of reasons. First is the fact that the training audience’s skills change with each succeeding event. For this reason, the trainer/facilitator may, for example, increase the difficulty level for a succeeding scenario. Variation is particularly important when highly cognitive skills, such as decision making, are being trained. If the decision-maker is repeatedly presented with the same set of circumstances, then situation assessment will become a vestigial process, and the training session invariably will be less effective or possibly result in negative training.

Another purpose of varying the exercise conditions is to reflect changes in the composition of the training audience. If a novice replaces an expert on the team, for example, the difficulty of the training event sequence may need to be adjusted. If new combinations of individuals or teams are aggregated into a higher level organization for a particular event, the exercise conditions should reflect the fact that the organization has not trained together.

4.5 Exercise conditions pertinent to learning objectives

To ensure that the desired behaviors are reinforced, it is necessary to relate the exercise conditions to the learning objectives. If the exercise is not structured with opportunities for the training audience to act in the desired way and to experience the consequences of its actions, learning will not occur effectively. If the training audience does not view the conditions as realistic (contextual) where the outcomes are directly related to the team's inter-actions with the environment, the training may not be perceived as meaningful, which again works against effective learning.

On the surface, this element and the previous one (the ability to vary exercise conditions) may seem redundant. However, given the ability to vary conditions, it is a jump in complexity to recognize and understand the relationships between learning objectives and exercise conditions. Those relationships comprise the essential ingredient in this element of the learning environment.

4.6 Exercise conditions adjusted for existing skills of the training audience

The exercise conditions must also be adjusted to reflect the skills of the training audience. In this context, the exercise conditions are commonly summed up using the term "difficulty". That is, the higher the skill level, the greater the difficulty. However, the relationships with the training audience are more complex than the single measure suggested by focusing on difficulty. If the training audience consists of more than one individual, skills may develop at different paces. Certain skills may require more experience opportunities than others may, even if the level of difficulty is the same. As suggested by the constructivist approach, the training strategy itself may change with advancing skill level, from a highly structured and controlled environment to one that is less so. As in the case of learning objectives, the training audience's skills comprise a fairly complex set of independent variables that must be understood in the process of specifying exercise conditions. Learning is an iterative, building block process and through the systematic adjusting of the contextual environment relative to complexity and difficulty, the training audience can collectively acquire the competencies needed to obtain maximum performance from their operational systems under adverse changing conditions. The desired outcome can be visualized as an ascending spiral with the team competencies increasing with each training session.

4.7 Meaningful exercise conditions

To foster effective learning, it is not sufficient for the exercise conditions to reflect the learning objectives and the training audience's existing skills; the training audience must also perceive the entire exercise as meaningful. In simulation terms, this corresponds roughly to the scenario being realistic. There is a difference between realism in the scenario and realism in the training audience's interactions with the environment (discussed in paragraph 4.2). Realism in interactions is primarily a function of the simulation models and training system infrastructure. This type of realism is built into the system by the developers. Realism in the scenario is built into the exercise by the trainer/facilitator and/or by a scenario author. Learning will not occur effectively if the scenario is perceived as being unrealistic, even if all the object models are very realistic. The closer the scenario is to the training audience's actual or anticipated mission situation, the better and more lasting the learning will be, because the learning will be perceived as more meaningful. The role of the trainer/facilitator is work with the team to determine where the team is relative to the desired competencies and set the training objectives for the next training session. In working with the team, The facilitator considers several variables in selecting the exercise scenario; these include the competencies to be trained, the training audience's experience and demonstrated task and team competencies. The facilitator adapts the scenario to provide multiple opportunities to demonstrate the desired competencies within the expected operational context. Further, both learning of team and task skills are enhanced (learn more in less time) by conducting relevant problem solving events within a contextual environment. As the team demonstrates what they know with the contextual environment (reflection in action) appropriate measures of performance must be non-intrusively collected.

4.8 Timely and relevant feedback to the training audience

As noted in the discussion of the learning theories, feedback to the training audience is fundamental to the learning process. The requirement for "timeliness" is fairly straightforward. The concept of temporal pairing suggests that there must not be an undue delay from action to feedback. Timeliness is easy to measure. Achieving "relevance" is more difficult. In complex training situations, especially those involving large teams and highly cognitive skills, the action's impact on the environment and the situation's outcome might be very indirect and not immediate. There may be cumulative effects which are difficult to relate to the training audience's competencies, but which are nevertheless precisely the effects being sought through the training process. For learning to occur effectively in this situation, feedback products must be created which reflect the intrinsic value of the desired behavior, but which can be recognized by the training audience to be the direct result of acquired competencies. Otherwise, the learning is not meaningful in the context of the learning objectives, and learning will not transfer to the long-term memory. Again, this is a complex relationship, which the trainer/facilitator must take into account when structuring the exercise conditions, and the data collection and AAR (After Action Review) strategies.

4.9 Facilitation of after action review

Effective learning requires that the training audience have sufficient opportunities to experience the environment, act upon it, and understand and reflect upon its actions and their relationships to the outcome of the situation (i.e., to the actions' consequences). The role of the trainer/facilitator after the exercise is to facilitate the processes of understanding and reflection. The process of facilitation is quite different from the traditional, pedagogic process of "delivering feedback" to the training audience. The facilitator must allow the training audience to "self-discover," through dialogue conducted around relevant topics such as situation assessment and leadership. The team through reflection-on-actions uncover the relationships between actions and outcomes and change their perceptions; they collectively learn. The contribution of the facilitator is to help the process through guidance, team facilitation techniques, and the furnishing of external reference data (e.g., ground truth data). The facilitator is critical to the process.

5. Conceptual Model of the Learning Environment

In recent years, the design of training systems has undergone a migration toward a **learner-centered approach**. A key motivator of this migration has been the increased attention on the question of the learning effectiveness of simulation based systems. In addition to considering technology and human components, learner-centered designs focus on incorporating features that create efficient and effective learning environments.

LEARNING METHODOLOGY MODEL

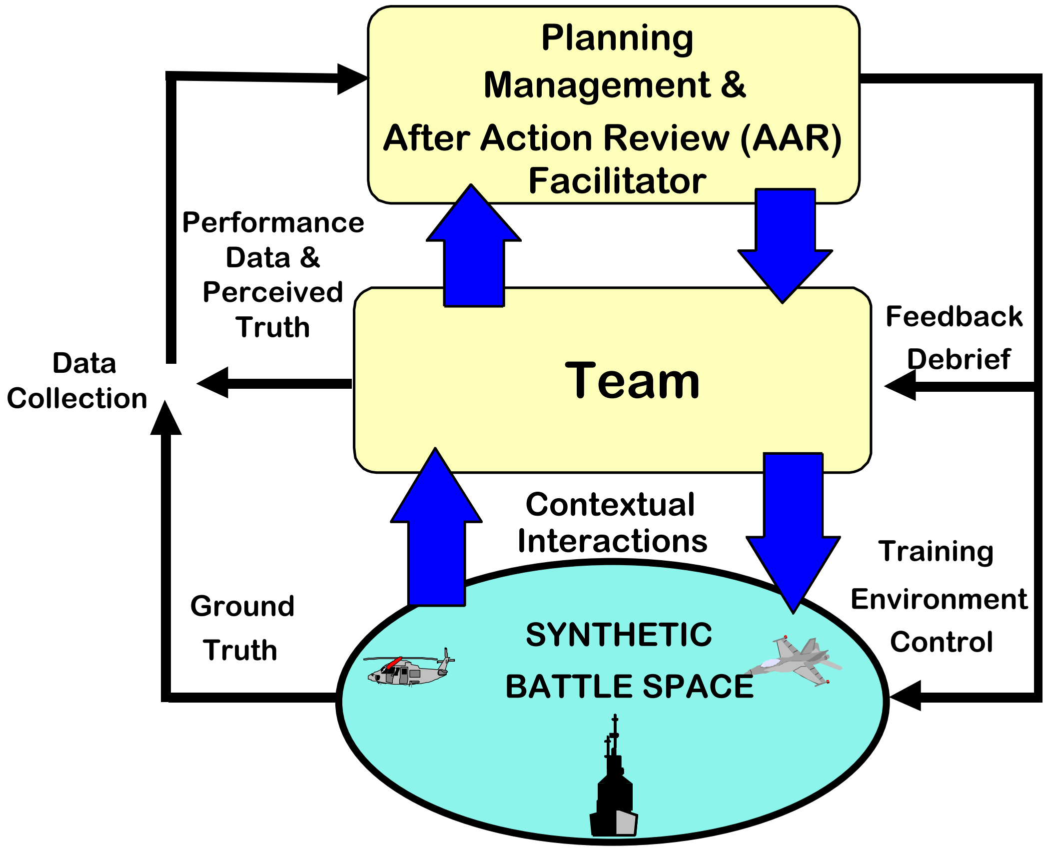

Figure 1. A Conceptual Learning Model

Effective learning environments are systems that enable a training audience to develop the competencies necessary to perform required tasks. Creating such environments requires an understanding of the learning process so as to structure learning opportunities using appropriate methods, strategies, and tools. One way to conceptualize a learning model is shown in Figure 1. The model is based on the concept that the most effective way to develop task and team skills is to provide opportunities for trainees to practice those skills within a contextual environment coupled with effective After Action Reviews (AAR). One method of AAR is referred to as post reflective dialogue. Post reflective dialogue is defined as a reflection-on-action process wherein the training audience reflects (relives) what occurred during the execution phase, explicitly challenging perceptions of what happened, and, through honest dialogue, changes individual and collective perception.

In the model, the contextual environment (Synthetic Battle Space) is generated based on the task, learning objectives and training audience's skill level. The training audience is immersed in the contextual environment where the outcome is dependent on the trainee's ability to collectively problem solve within a rapidly changing environment.

As the trainee interacts with the environment, data is collected, merged and stored. Data collected includes ground truth, perceived truth and performance data. Ground truth is the situation and the environment as presented to the training audience and as it reacts to the training audience's actions. Perceived truth is what the training audience sensed through its interfaces with the environment (for example, a C4I display). Performance data is information on how the training audience dealt with the situation as presented, and as it developed during the exercise. Performance data relates to both task outcomes and team processes and includes both data collected automatically by the system and data entered by observers.

During an exercise, the training audience's performance is monitored, and the complexity of the environment adjusted as appropriate based on skill level. After conduct of the interactive exercise, a facilitated, learner-centered After Action Review session is conducted. In this session, the training audience (supported by relevant feedback products) re-creates what happened during the demonstration period and challenges the results of actions taken. It is during this phase that perceived truth is aligned with ground truth and "discovery learning" takes place. By completing cycles around this model, the training audience continues to build proficiency in both task and team skills, which have a direct impact on combat readiness. The team asks the three basic questions: What happened? What should have happened? What do we want to do about it?

To be effective, learning environments must employ systematic, deliberate approaches in order to ensure knowledge and skill acquisition and retention by the training audience. Therefore, certain disciplines need to govern the application of the model to real training situations. For example, efficient learning requires the presence of specific, pre-planned opportunities for participants to demonstrate and receive feedback in targeted competencies (knowledge and the skill to collectively use that knowledge). The introduction of these opportunities must be transparent; otherwise, the training audience may not perform in a realistic manner. *Uncontrolled free play, without learning opportunities and associated reflection-on-action, is not a viable training strategy*. At the same time, scenarios must not be so constrained that the trainee loses interest. A well-designed scenario provides a contextual free play backdrop interlaced with several structured unexpected learning objectives. Such a scenario allows the team to meaningfully demonstrate what they know to resolve new problems.

A systematic approach must also be applied to data collection. Learning environments must employ a coordinated data collection scheme to provide effective AAR products on targeted tasks and competencies. The method used for data collection must be non-intrusive; the data collection process should not require that trainees to modify their operational behavior. Based on systematic data collection, feedback will support reflective learning and thus improve performance. It is important to collect data related to outcomes (i.e., was the right decision made?) as well as processes (i.e., was the decision made right?). Outcome measures of performance (MOP) and measures of effectiveness (MOE) provide important information regarding overall performance. Process measures provide information on the underlying tasks, sequences of behaviors, and team dynamics that achieved the given outcome.

The learning model supports the types of disciplines required to ensure an effective learning environment, but it does not guarantee that those disciplines will actually govern training. The first step in ensuring that the appropriate disciplines are actually applied is to design the training system so that it supports a systematic and disciplined approach to structuring an effective learning situation. This is the focus of the LMWG for both the BFTT and JSIMS thought processes and development efforts.

6. The LM Process Model

During the collaborations leading up to the formation of the LMWG, a LM process model was developed by representatives of the military and joint service component training system user communities and the behavioral science research community. This model is depicted in Figure 2. The model reflects both the shared conceptual model of the learning environment, discussed in Section 5, and actual experience with simulation based training systems within the military services. The process model thus represents the fusion of learning theories and practical experience in joint and each of the military service component training environments.

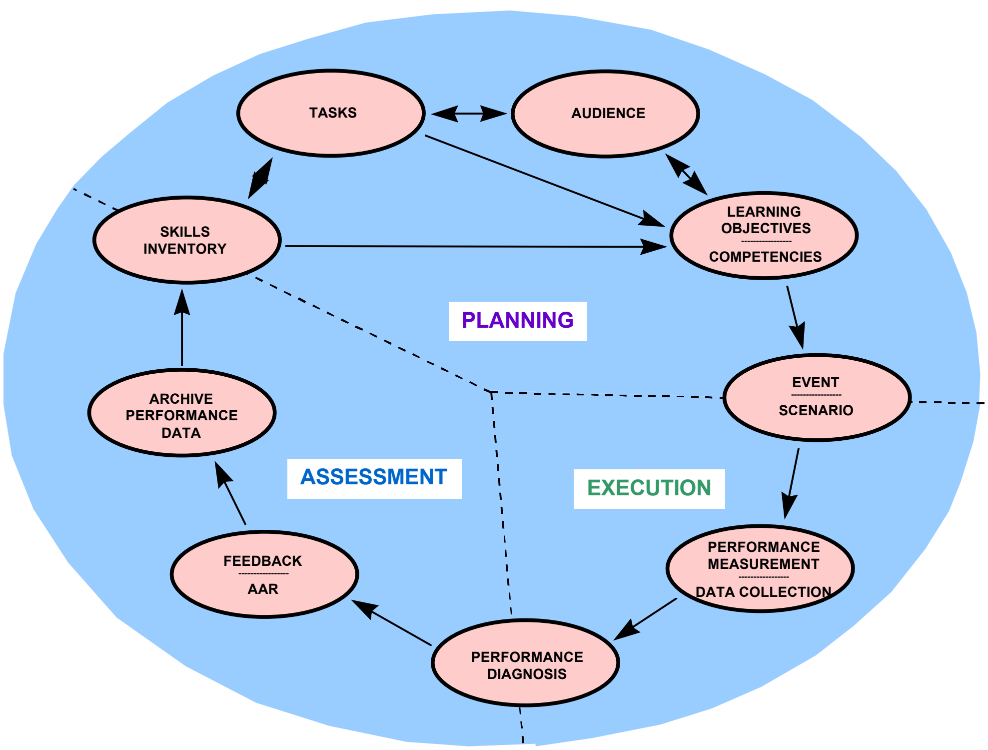

Figure 2. LM Process Model

It should be noted that the synthesis of the LM process model was not the result of negotiation and compromise among the service representatives. On the contrary, the initial discussions revealed that the learning process and the discrete steps comprising it are indeed common among the services, except for some nomenclature differences. This fact should come as no surprise, since learning is the common objective, and learning involves a human behavioral process that does not vary from one military branch to another.

The value of the LM process model, and the main reason for incorporating it into this Reference Document, is that it is a means of expressing LM requirements in terms of a tangible process that is consistent with each of the services' and joint training environments. It provides the basis for changing the current training infrastructure and culture. This is considered a crucial step in the translation from theory to practice.

In the paragraphs that follow, the components of the LM process model are described. Then, in Section 7, a set of specific LM requirements for simulation based training are expressed in terms of those components and their interactions.

6.1 Planning Phase: Audience and Tasks

Effective training begins with a clear understanding of who the training audience is and the training requirement, expressed in terms of mission-essential tasks. One source of task definitions is the Universal Joint Task List (UJTL). The UJTL provides a detailed listing of tasks, conditions, and standards that comprise the missions to be performed by a joint military force. There are other useful sources as well, including National Military Strategy, Assigned Missions, Commander's Intent, Joint Doctrine - Joint Tactics, Techniques, and Procedures (JTTP) and service component tactical task lists. The definition of the training audience and the required tasks comprise the independent variable of the training event.

6.2 Planning Phase: Skills Inventory and Learning Objectives/ Competencies

Based upon the training audience and targeted tasks, the task-based learning objectives are identified. These learning objectives represent the "deltas" between the existing skills, as represented in the skills inventory, and the mission-related task requirements.

Part of the discipline of an effective learning environment is the establishment of Measures of Effectiveness (MOEs) and Measures of Performance (MOPs) for each learning objective. MOEs are process measures; they emphasize those actions taken to reach a performance end state. MOPs are *outcome* measures; they focus on the End State achieved. MOEs provide data to answer "was the decision made right?" while MOPs provide data to answer "was the right decision made?"

Selected MOEs determine the data set to be collected and the associated AAR feedback products. The data collection infrastructure and tools should provide an ability to identify trends during the exercise, support the development of diagnostic performance feedback, development of external reference products and assess the extent to which learning objectives were achieved. Data collection across multiple events for a specific learning objective enables one to assess how well an individual or team performed on similar objectives over a range of conditions.

6.3 Planning Phase: Event/Scenario

Once the learning objectives are identified, it is necessary to select or create "trigger events" for each learning objective and incorporate these into a scenario. This process reflects the guiding principle that the training must be structured in a disciplined fashion, with a continuously applied understanding of the specific learning objectives. The trigger events create specific opportunities for the training audience to practice critical tasks and competencies in a contextual environment, and to experience the consequences of their actions. Typically, a number of events are created for each learning objective that vary in difficulty and occur at different points in an exercise. This not only provides opportunities to reinforce behavior, but also increases the confidence in the results.

Once the task requirements, learning objectives, trigger events, MOPs, MOEs, and data collection strategies are known, they are amalgamated into a coherent scenario related as closely as possible to the expected mission or operational use of the training being undertaken. Scenarios must permit the training audience to interact in realistic situations that will facilitate transfer of learning from the training environment to the operational situation. Scenarios can use a wide range of constructive, virtual, synthetic, and live resources. Regardless of the specific resources used to create the training environment, the scenario must support the learning objectives, enable the required events to be presented to the participants, and facilitate the collection of data for feedback on the established MOPs, MOEs and other relevant facts and data.

6.4 Execution Phase: Event/Scenario

After the scenario is generated and tested, it is used to create the synthetic battle space environment for the training audience. This represents the transition from Planning to Execution. Exercise management and control of exercise flow are critical aspects of this process. Training participants must be permitted to make their own decisions (reflection-in-action) and to handle the presented situation consistently with doctrine. At the same time, exercise managers must ensure that opportunities are presented which are aligned with the exercise objectives. Critical features of exercise management function include: tracking the occurrence of events and collecting data during those events, ensuring that contingency plans are in place to maintain exercise continuity if there is a failure or anomaly, and monitoring. If necessary, the exercise management function allow adjusting scenario scripts to ensure the exercise unfolds in a way that meets exercise objectives.

6.5 Execution Phase: Performance Measurement/Data Collection

As the training audience performs within the contextual environment, data is collected to support feedback. An important aspect of this function is the fusion of data, from multiple sources, associated with a particular event and associated training audience actions. When an event occurs, relevant ground truth, perceived truth, and performance data must be collected and time stamped. The resulting information can be documented, analyzed, and packaged to provide critical feedback products.

6.6 Execution Phase: Performance Diagnosis

Performance diagnosis begins in the Execution Phase. Near-real-time assessments permit the trainer/facilitator to monitor performance and ensure that learning objectives are being met. If appropriate, various components of the situation can be adjusted as to difficulty, or new events can be created to target specific skills. If appropriate, a training event can be truncated if it becomes evident that continuation of the event would not be productive.

6.7 Assessment Phase: Feedback/AAR

Through facilitated team AAR dialogue and use of feedback products, the training audience can determine what happened, why it happened, and what they could have done to improve the outcome. Feedback products enhance the ability of the team to relive the exercise and provide external reference information that supports non-threatening changes in both individual and team perceptions (learning). The after action review products integrate ground truth data with perceived data and performance measurements. Feedback elements are based on the MOPs and MOEs, which in turn are linked to the trigger events and learning objectives. This approach provides an integrated structure and control to training that ensures internal consistency throughout an exercise. Feedback must be timely and in a form that is relevant to the task at hand and flexible enough to accommodate varied learning styles.

6.8 Assessment Phase: Archive Performance Data

Following the completion of the exercise, appropriate data is stored and archived in a manner that supports the development of lessons learned. Data collected across exercises can facilitate the development of normative databases that would indicate problem areas and may suggest new instructional strategies.

6.9 Assessment Phase: Skills Inventory

Archived data includes a skills inventory database. The skills inventory is updated each time an exercise is conducted. Updated skills inventories are then used in the planning of subsequent exercises. The skills inventory thus represents the transition from one cycle to the next in the LM process model and provides an updated baseline for follow-on exercise planning process.

7. Specific LM Requirements

This section presents a set of specific LM requirements for a hypothetical simulation based training system. The purpose of including such a list in this reference document is to provide insights into the nature of LM related requirements and training simulation software components might be affected by invoking them. This list does not constitute a specification of any specific system, nor is it the result of an engineering analysis of requirements for any particular system. It is an independent expression of those requirements that support the precepts of LM.

Many of the listed requirements are self-explanatory. *[Others are explained in brackets, in italics.]*

The first subsection below lists requirements not related to specific capabilities. Following that are several subsections listing capabilities that support LM, generally categorized with respect to the LM process model components discussed in Section 6.

7.1 Requirements Not Related to Specific Capabilities

These requirements are expressed as general criteria that should be applied to any of the tasks or capabilities described in the subsequent subsections. These requirements address a mix of efficiency and effectiveness issues.

- Shorten clock time or calendar time to perform a function.
- Reduce labor hours to perform a function.
- Reduce skill level requirement to perform a function.
- Reduce the incidence of errors.
- Generate recommendations in support of decisions and selections.

7.2 Requirements Related to Tasks

- Accept task definitions from authoritative sources. *[The system should accept task definitions from existing sources without requiring re-formatting or re-keying.]*
- Let the trainer/facilitator modify task definitions.
- Link tasks to performance standards.
- Relate a new tasks to skills and standards. *[The user should be able to create a new task definition that is automatically to the existing skills inventory and performance standards, based on the new task's relationship to an existing task.]*
- Represent tasks at different levels of aggregation. *[The system should automatically link a given task with the same or higher level tasks at higher organizational echelons.]*
- Allow missions to be defined in terms of tasks. *[The trainer/facilitator should have the option of specifying training requirements in terms of missions, as well as individual tasks.]*
- Allow requirements to be defined in terms of either tasks or missions.
- Suggest and allow editing of task list for a specified mission and training audience.
- For specified mission and set of actors, provide a skills assessment. *[Skill assessment is the delta between proficiency required for the mission and skills presently held by the training audience.]*
- Automatically "decay" the skill assessment over time.

7.3 Requirements Related to Training Audience

- Allow the training audience to be specified as an individual, an organization, or a collection of individuals and organizations.

7.4 Requirements Related to Learning Objectives

- Report the skills inventory for the specified training audience as it relates to the specified mission or task set.
- Recommend learning objectives based on mission or task requirements, training audience and skills inventory.

7.5 Requirements Related to Events/Scenarios

- Recommend a sequence of training events leading to achievement of required competencies.
- Sequentially aggregate up to highest specified echelon. *[The sequence of training events may progress logically up through higher levels of aggregation.]*
- Incorporate repetition as required. *[Consider the training audience's learning capability in setting the number and timing of repetitions.]*
- Incorporate variation as required. *[This includes variation for randomness, for increasing difficulty, changing skill mixes within the training audience, and progression from more to less structure training situations based on level of expertise.]*
- Establish exit criteria for each training phase. *[Not all learning objectives need to be met in order to advance to a subsequent phase.]*
- Recommend training system configuration.
- Allow prompted editing of training system configuration. *[Prompts should suggest potential conflicts between training system configuration and the intended training audience, scenario, and/or data collection strategy.]*
- Recommend and allow editing of the trainer/facilitator staffing and organization to support a specified event.
- Recommend sequence of event preparation steps.
- Recommend building blocks (vignettes) for constructing each training event. *[Vignettes would be linked to specific learning objectives, and they would incorporate trigger events.]*
- Relate the mission requirements to a geographical area. *[It should be possible to define location-specific missions, or to overlay a selected mission on a specified location.]*
- Relate the entity mix (live vs. simulated entities) to the specified learning objectives. *[A particular scenario may be executed with different mixes of live and simulated entities, depending upon who is being trained.]*
- Build a coherent scenario from selected vignettes.
- Develop coherent sequences of scenarios. *[Avoid overlapping benefits and duplication of effort, thereby optimizing use of simulation resources.]*
- Relate each scenario to organization echelon. *[Link the same or similar scenarios used at different levels of aggregation]*.
- Adjust model fidelity to fit the learning objectives, scenario and training audience.
- Recommend and allow editing of the scenario initial conditions.

7.6 Requirements Related to Performance Measurement/Data Collection

- Set forth performance measurement (data collection) requirements for each scenario.
- Relate performance measurement (PM) requirements to learning objectives for specified phase of training.
- Relate PM requirements to exit criteria for specified phase of training.
- Relate PM requirements to organization echelon. *[Different data will be collected at different levels of team aggregation.]*
- Ensure scenario events and PM requirements are consistent. *[Highlight potential conflicts between the scenario and apparent PM requirements.]*
- Relate MOPs and MOEs to learning objectives.
- Relate MOPs and MOEs to mission tasks.
- Relate MOPs and MOEs to overall mission effectiveness.

7.7 Requirements Related to Performance Diagnosis

- Base performance diagnosis on MOPs and MOEs.
- Report the effects of observed MOPs and MOEs on task and mission effectiveness.
- Extrapolate performance trends during the exercise to projected achievement of learning objectives.
- Report if difficulty level appears too high or too low for all or part of the training audience. *[Recommend adjustments to the scenario if appropriate.]*
- Assess and report on learning effectiveness of a given training event or sequence of events. *[Learning effectiveness criteria need to be defined.]*

7.8 Requirements Related to Feedback/AAR

- Allow trainer/facilitator to customize AAR products.

7.9 Requirements Related to Archive Performance Data

Analyze and report trends across successive events, with regard to specified set of competencies and specified training audience.

- Allow retrieval, fusion and analysis of archived performance data by selected individual or organization. *[Data should be available for a selected organization, regardless of the level of aggregation of the training event in which that organization participated.]*
- Recommend type, timing, and echelon of a subsequent training event. *[Recommend an adjustment to a previously planned interval between events, if observed performance so warrants.]*

7.10 Requirements Related to Event Planning and Management

- Maintain schedule of planned events.
- Report scheduled events by member of training audience, organization, task, mission, date or location.
- Report potential conflicts in scheduling of training audience or training location.

8. Training Effectiveness Evaluation

One of the most critical components of the Learning Methodology is measures of effectiveness. How do we evaluate whether the simulation is achieving its original objective: training? And how do we determine *how well* it is providing an effective learning environment? The following provides a framework for applying this part of the process to large scale training simulation systems and discusses the criticality of determining evaluation procedures **before** the build stage begins.

8.1 Proposed Training Effectiveness Evaluation Framework

8.1.1 Overview

This section develops and describes a proposed training effectiveness evaluation framework for large scale simulation training systems. First, it explores the rationale for evaluating training systems such as a BFTT or a JSIMS. Second, it develops a framework based on that rationale. Third, it presents the framework. Finally, it describes some of the tools that the training system needs to include to support evaluation.[1]

[1] The DoD Office of the Inspector General (DoDIG) recently conducted an audit concerning the impact on readiness of training simulators and devices (DoDIG, 1997). The audit focused particular attention on shortcomings in evaluation of large-scale simulations. The Services have little experience evaluating these simulations and there are no standard evaluation methods. The audit recommended that DoD establish policy and procedures for evaluating the training effectiveness and cost-effectiveness of large-scale training simulations. In response, the DoD committed to developing policy and guidelines for conducting cost-effectiveness analyses of large-scale training simulations that allow analysts to select the best evaluation method under the circumstances, describe the procedures

8.1.2 Rationale

Why Evaluate? Evaluations are conducted for a number of different reasons; obvious ones are to:

1. Satisfy milestone requirements
2. Assure that system performance standards are met
3. Demonstrate cost and training effectiveness
4. Identify and correct developmental deficiencies
5. Identify and correct deficiencies in the management and use of training systems
6. Monitor competencies to support planning and execution of training events

All of these are sound reasons to evaluate. From a purely training standpoint, however, the focus shifts to reasons 2, 3, and 4: 2 and 3 because they show that the system works well and justifies its cost in some relatively mature end state; 4, because evaluations can help identify system shortcomings that can be corrected during development.

8.1.3 Evaluation as TQM

As we tend to think of evaluations as one-shot events that provide definitive results, the least obvious of these reasons to evaluate is 4. Evaluation conducted for this reason suggests that evaluation (1) is not an event but a *process*, (2) is a technique for improving the system being evaluated, and (3) may or may not provide definitive results. In other words, evaluation can be thought of as similar to Total Quality Management (TQM), wherein data pertaining to a process are gathered and analyzed, the process is critiqued, and corrective actions are taken to improve the process and where data pertaining to the revised process are gathered, analyzed, and so forth, in an endless cycle.

8.2 Building an Evaluation Framework

In thinking about evaluation, it is useful to start by asking basic questions; e.g., *how*, *what*, and *when* should I evaluate? These three questions take on more specific meanings in the context of an actual evaluation:

- How should I evaluate? (What evaluation *methods* should I use?)
- What should I evaluate (What *dependent variables* should I measure?)
- When should I evaluate (How should I conduct evaluation events in terms of *time*?)

8.2.1 How Should I Evaluate? (Methods)

Many different evaluation methods are available. The Defense Manpower Data Center (DMDC) is currently compiling data on several hundred military training system evaluations. Work to

---

for the various methods, and provide examples that may be used as models to emulate (Kaminski, P.G. [1997, March 17], p. 6). This work, currently in progress, forms the basis for the present section.

date indicates that evaluations tend to use one of four main methods: *experiment, opinion, extrapolation,* or *analysis*. (Different methods are often used in combination; e.g., experiment and opinion.) Each of the methods can, in turn, be performed in several different ways, comprising a set of submethods (Table 1).

In simple terms, here is how the methods are applied:

- Experiments empirically determine effectiveness based on *objective* data.
- Opinion-based evaluations empirically determine effectiveness based on *subjective* data.
- Extrapolation-based evaluations make predictions based on past experience or existing data.
- Analytical evaluations compile data systematically and reach conclusions based on pre-determined rules of evidence

Method	**Submethods**
Experiment[2] (50+% of cases)	Ex post facto
	Pre-experiment
	Quasi-experiment
	Test
	Transfer
	True experiment
Opinion[3] (30±% of cases)	Analysts
	SMEs
	Users
Extrapolation[4] (<10% of cases)	Analogous system
	Historical data
	Model
Analysis[5] (<10% of cases)	Functional analysis
	Survey
	Task performance analysis

Table 1. Common Evaluation Methods and Submethods

Based on currently available data (Table 1), the most commonly used methods are experiment (50+% of cases) and opinion (30±% of cases). Extrapolation and analytical evaluations are used in fewer than 10% of cases each. Why do these relative numbers differ? Some possible reasons:

- Acquisition regulations generally encourage experiments.
- Among most evaluators and military decision makers, experiments have greater face validity than other methods.
- Opinion data are generally less difficult and costly to obtain than data from experiments and so tends to be used when experiments are not possible.

---

[2] Submethods for this method are defined based on descriptions in Campbell & Stanley (1966). These submethods vary greatly in terms of the cost and difficulty of conducting them and in the authority of the conclusions based on experimental outcomes. Unfortunately, this subject is beyond the scope of the present document. It will be covered in detail in Simpson & Cohen (in preparation).
[3] Submethods are defined in terms of the group whose opinion is gathered: analysts, SMEs, or users.
[4] Submethods are defined in terms of what data and/or schema are used as the basis for extrapolation: an analogous system (e.g., predecessor to current system), historical data, or mathematical model.
[5] Submethods are defined in terms of what type of data are gathered to drive the analysis; e.g., from system functions, a survey, or task performance.

Note that, to use either of these methods (experiment or opinion), the training system *must exist and be functional*. On the other hand, extrapolation and analysis can be performed without a functional training system. Extrapolation and analysis tend to be used in two main cases:

- The system is insufficiently developed to conduct an experiment or gather opinion data.
- Evaluation resources are limited.

8.2.2 What Should I Evaluate? (Dependent Variables)

Many different dependent variables have been used in evaluating large-scale simulations. To date, no set of variables has gained universal acceptance. Thus, it is necessary to start from basics.

Kirkpatrick (1976) recommends that training programs[6] be evaluated at four levels: *reaction, learning, behavior,* and *results*. Data gathered at each of these levels answer different questions about the effect of the training program on its students:

- Reaction - How well did students *like* the program?
- Learning - What did students *learn* while participating in the program?
- Behavior - How did *job behavior* change after the program?
- Results - What were the *tangible results* after the program in terms of reduced cost, improved quality, improved quantity, etc.?

Note that (1) reaction and learning data are gathered during training and (2) behavior and results are gathered after training. Typical ways to gather data for each of these levels would be reaction (post-course questionnaire), learning (in-course tests), behavior (post-course supervisor performance evaluations), results (post-course productivity/quality of the student's work center).

Some authors familiar with large-scale simulations have made specific recommendations concerning dependent measures to use. Hiller (in press) recommends that evaluators focus on (1) task and mission performance outcomes, (2) processes, and (3) a user evaluation. Bell, Dwyer, Love, Meliza, Mirabella, & Moses (1997) recommend that evaluators measure both system processes [such as interactions among team members] and combat outcomes.[7] Garlinger & Fallesen (1988) recommend that evaluators focus on (1) user acceptance, (2) processes, and (3) achievement of system goals. Alluisi (1991) makes the case that post-training readiness is a relevant dependent measure.[8]

---

[6] A large-scale training simulation is not a training program, although the two have much in common.

[7] The focus on team processes is an important difference between evaluating the typical training program and a large-scale simulation. Generally, training programs deal with individual training and performance while a large-scale simulation deals with the additional factor of team and/or collective training and performance.

[8] Alluisi made this case regarding the evaluation of SIMNET: "For SIMNET to be viewed by the Army as successful--that is, as an effective training system that is worth the expenditure of funds for additional procurement--the Army will have to be convinced that it will make a difference in readiness."

The consensus of these experts is that evaluators should use a combination of opinion, process, outcome, and product measures. These suggestions extend Kirkpatrick's list by adding two variables to measure during training (team processes, mission performance outcomes/achievement of system goals). Alluisi's readiness variable fits into Kirkpatrick's post-training *results* category; by extension, this category might be extended to include other logical post-training mission-related outcomes; e.g., performance in combat.

Taking into account the foregoing, here is a consolidated list of dependent measures that combines Kirkpatrick and the large-scale simulation experts:

1. Reaction - How well did students *like* the simulator?
2. Learning - What did students *learn* in the simulator?
3. Processes - How well did teams (and other collectives) perform in the simulator?
4. Outcomes - What were the *tangible results* (simulated combat outcomes: exchange ratio, % losses by force, shots/kill, etc.) during training?
5. Behavior - How did individual and team *job behavior* change after training?
6. Results - What were the *tangible results* after training (readiness, field exercise performance, combat outcomes)

This scheme uses six different variables. Note that:

- The first four (Reaction, Learning, Processes, Outcomes) are obtained in the simulator. The last two (Behavior, Results) are obtained post-training.
- Variables 3 and 5, and 4 and 6 are analogous pairs; the first number reflects performance during training and the second post-training.[9]

8.2.3 When Should I Evaluate? (Timing)

Noted earlier: We tend to think of evaluations as one-shot events that provide definitive results. This may make sense when evaluating simple things that already exist (e.g., an inexpensive training method or medium). It does not make sense when evaluating complex and expensive training simulators such as JSIMS that undergo years of development before becoming operational.

Table 2 summarizes the timing of evaluation events. Evaluation occurs in four phases, represented by the four right-most columns: *I. Prospective, II. Developmental, III. Milestone,* and *IV. Follow-on.* The far-left column indicates what entries appear in the cells: *When* (timing of events), *Purpose* (why evaluation event is conducted), and *How* (the evaluation method employed).

Evaluation is a lengthy process that should start *before* the system exists. Some purposes of evaluation at this phase are:

[9] In conducting military training, an implicit assumption is that performance during training will affect job performance, which in turn will affect combat readiness, which in turn will affect combat performance (Solomon, 1986). In other words, it is expected that old learning (e.g., on simulator) will affect performance in a new situation (e.g., in combat). This is the definition of *transfer of training.* The two sets of variables just described provide a mechanism for measuring transfer.

- Estimate perceived need for and training potential of system
- Define/refine training content
- Assure adequate learning environment

These questions can be addressed using analytical and opinion-based analyses; it may be possible to use extrapolation.

Later, during system development, hardware and software capabilities will be built, in stages, and it will become possible to evaluate these fledgling capabilities. Some purposes of evaluation at this phase are:

- Demonstrate training effectiveness of *functioning subsystems*
- Assess/refine design
- Estimate user acceptance

These questions can be addressed based on opinion (user acceptance) and simple experiments (functionality tests, user in-device learning experiments).

Table 2. Proposed Evaluation Framework
Illustrating Purpose and Evaluation Methods by Evaluation Phase

DESCRIP-TION	**EVALUATION PHASE**			
	I. Prospective	**II. Developmental**	**III. Milestone**	**IV. Follow-on**
When	Before system exists	During system development	At major developmental milestones (builds, IOC, FOC)	After system becomes operational
Purpose	• Estimate perceived need for and training potential of system • Define/refine training content • Assure adequate learning environment	• Demonstrate training effectiveness of *functioning subsystems* • Assess/refine design • Estimate user acceptance	• Demonstrate training effectiveness of *total system* • Assess/refine design • Determine user acceptance	• Estimate transfer of training • Determine effects of training on readiness, use of resources, & overall performance
How	• Analysis (functional analysis) • Analysis (survey) Opinion (SMEs)	• Opinion (user) • Experiment (pre-) • Experiment (test) • Experiment (quasi-)	• Opinion (user) • Experiment (quasi-)	• Opinion (user) • Experiment (ex post facto)

As development proceeds, certain milestones will be reached during which relatively mature system capabilities are expected to be demonstrated. At these points, and at the end of development, purposes of evaluation are:

- Demonstrate training effectiveness of *total system*
- Assess/refine design
- Determine user acceptance

These questions can be addressed based on opinion (user acceptance) and quasi-experiments[10] (individual and team learning and simulated combat outcomes).

After the system becomes operational, it is possible to accrue data to ask questions that could not be addressed during development. Some purposes of evaluation at this phase are:

- Estimate transfer of training
- Determine effects of training on readiness, use of resources, & overall performance

These questions can be addressed based on opinion and ex post facto experiments to estimate effects of training on readiness and transfer to operational setting.

---

[10] True experiments (involving separate experimental and control groups) are not an option when evaluating a system such as JSIMS , as there is no non-JSIMS experimental condition to use as a control.

When is evaluation complete? Proponents of TQM would argue that evaluation is never over, as the system can always undergo further refinement. A more realistic answer is that evaluation ends when the body of accumulated evidence persuades decision makers that the system is successfully met its goals in terms of training, cost reduction, supporting combat readiness, etc.

8.3 Evaluation Framework

8.3.1 Evaluation Principles

Following are the principles upon which the evaluation framework is based:

- Evaluation is a process, not an event
- Evaluate (1) longitudinally (across time) and (2) vertically (across measures)
- Attempt to influence design & development
- Obtain the best data that you can, based on (1) state of development and (2) resources
- Assure that data are relevant (reflect the variable of interest), valid, and reliable.
- Develop human learning curves
- Measure for transfer of training

Combining these principles with the *how*, *what*, and *when* of evaluation already described leads to the evaluation framework shown in Table 3.

Table 3 summarizes the timing of evaluation events in terms of the evaluation measures and methods used during each evaluation phase. The four phases of evaluation are presented in the four right-most columns: *I. Prospective, II. Developmental, III. Milestone,* and *IV. Follow-on.* The far-left column indicates what type of evaluation measure is used. Entries in the cells indicate what evaluation method is used to obtain each type of measure.

Note that many cells are empty (entry is N/A). This means that no data for the measure are collected for that particular phase because it is impossible to collect such data. For example, the cell represented by column *I. Prospective* and row *Results* is empty because this kind of data cannot be collected until an operational system exists and can be tested.

The methods indicated in the cells are used to obtain the type of measure listed in the *Measure* column. For example, the cell represented by column *II. Developmental* and row *Learning* contains the word "experiment," indicating that experiment is used to collect Learning data.

Table 3. Proposed Evaluation Framework
Illustrating Measures and Evaluation Methods by Evaluation Phase

MEASURES	**EVALUATION PHASE**			
	I. Prospective	**II. Developmental**	**III. Milestone**	**IV. Follow-on**
Reaction	Opinion (SME): • Training potential • Perceived need for system	Opinion (user): • Value for training • Realism • Preferences for alternative design features • User suggestions	Opinion (user): • Value for training • Realism • Preferences for alternative design features • User suggestions	N/A
Learning	Analysis: • Adequacy of individual task lists • Opinion (SME): • Adequacy of learning environment	Experiment: • Effects of alternative design features on individual learning (subsystem level) • Individual learning on subsystems • Shape of individual learning curve on subsystems	Experiment: • Individual learning on total system • Shape of individual learning curve on total system	N/A
Processes	Analysis: • Adequacy of collective task lists	Experiment: • Team learning on subsystems • Shape of team learning curve on subsystems	Experiment: • Team learning on total system • Shape of team learning curve on total system	N/A
Outcomes	N/A	N/A	Experiment: • Simulated combat outcomes	N/A
Behavior	N/A	N/A	Opinion (users): • Predicted effects of training on future job performance	Opinion (users): • Estimated effects of prior training on current job performance
Results	N/A	N/A	Opinion (users): • Effects of training on readiness • Transfer to operational setting • Potential OPTEMPO tradeoff	Experiment (ex post facto): • Effects of training on readiness • Effects on field exercise performance • Actual OPTEMPO tradeoff

The methods that can be used vary with evaluation phase, depending upon how far the system has developed. In Phase I, the system does not yet exist and evaluation relies entirely upon opinion and analysis.

During Phase II, opinion data can be obtained regarding user perceptions and design preferences. In addition, subsystem level capabilities become available and some experimentation can occur.

During Phase III, more opinion data can be obtained regarding user perceptions and design preferences. System level capabilities become available and further experimentation is possible--extending now to *Outcome* measures. At this level of system development, it is reasonable to ask users to predict the effects of training on future job performance (*Behavior* measure) and estimate the effects of training on *Results* (readiness, transfer to the operational setting, and OPTEMPO tradeoff).

During Phase IV, evaluation focuses on events occurring during operational usage of the system following the Phase III evaluation. Users estimate the effects of training on their job performance (*Behavior* measure). Ex post facto experiments using archival data are conducted to estimate the effects of training on *Results* (readiness, transfer to the operational setting, and OPTEMPO tradeoff). Compare these two cells with comparable cells for Phase III.

8.4 Tools Needed to Support Evaluation

Evaluation events that rely on opinion, analysis, and extrapolation will usually be based on paper and pencil data collection instruments, protocols, etc., and are not expected to generate any special requirements in terms of system design.

Experiments conducted during Phases II and III will be based upon a variety of measures reflecting *Learning, Processes, Outcomes,* and *Results.* Some of these measures may be collected by assigned evaluators and/or observer/controllers (O/C). However, to facilitate efficient evaluation, it is necessary to provide a semi-automated evaluation data collection, storage, retrieval, and display capability. Tools need to be designed and developed to support these requirements.

The exact nature of this capability is not being defined here; rather, this is to identify a problem that needs to be addressed during system development--and sooner rather than later.

Tools are needed to support:

- Interface with O/C tools
- On-the-fly data acquisition
- Short, medium, and long-term data storage
- Retrieval & display for evaluation purposes
- Archival storage

The archival storage capability is particularly important in evaluating large-scale simulations because of the need to accumulate and integrate data over the long term to separate effects of training from confounding variables (Leibrecht, 1996; Boldovici & Bessemer 1994).

9. Conclusion

Simulation systems have rapidly become a critical part of the Department of Defense's overall readiness and training program within each service and at a Joint level. As the training paradigm has shifted from classroom to distributed technologies, the approaches for development and evaluation of the training components have been required to change as well. From instructor focused to technology focused we have moved beyond even the contributions of instructional system design. Learning Methodology provides the new paradigm shift to developing an *effective learning environment* through a systematic process which sees learning experts working in tandem with technical programmers and systems designers.

ISD, exceptional instructors, and subject matter experts are still needed in the overall training programs; but we are likely to see new job definitions that are a blend of skills from a variety of areas of expertise. As has been stated in this document, the Facilitator is critical to the success of the team learning process Further, the emergence of "learning engineers" is on the horizon. Those individuals who have service expertise but are trained to function as both liaisons among the various groups involved in building, using, and evaluating simulation systems and as the person responsible for ensuring an effective learning environment in their area of responsibility. The identification and development of these personnel will be critical as we introduce new large scale systems such as JSIMS and as we begin to re-engineer or refresh extant simulation systems such as BFTT to provide more accurate and effective training for today's broad and dynamic military requirements. Learning Methodology provides the framework that will move us to the new training paradigm required to build the most effective technical systems and to train with the greatest efficiencies. It is a new age for training—we know what technologies can do and we know that information is important; the question now becomes *how* to select and build the *most efficient* training systems—those that can provide a multitude of scenarios, identify quickest routes to information needed for the mission, and provide the maximum level of retention for the shortest amount of time and money.

GLOSSARY

Behavioral psychology: the study of overt human behaviors; emphasis is based on the belief that by studying the relationship between environmental events and behavior would lead to an understanding of why humans do what they do without references to their mental processes. Behaviorists (often called S-R psychologists) view environmental factors in terms of stimuli and resultant behavior in terms of responses.

Cognitive psychology: the study of mental process and of changes in an individual's knowledge that result from experience with a stimulus environment. Cognitivists delve into the internal processes by which an individual deals with the complexity of his environment. They also try to define the resulting cognitive structures that he constructs in his mind: the ways in which he perceives and conceptualizes his physical and social world. An important assumption of cognitive theory is that an individual's behavior is always based on cognition, the act of knowing about the situation in which behavior occurs.

Competency: suitable or sufficient skill or skill level, knowledge, or experience
to perform a task. A specific job may require multiple competencies. Or a corporation may have several competencies; i.e. several business bases at which they are equally successfully competitive.

Constructive psychology: based on the belief that learning is a self-assembly process

Discovery learning: the learner organizes into final form the material to be learned.
Discovery learning is like wrapping your own package, reception learning (or didactic teaching) is like having someone open it for you. Jerome Bruner receives primary credit for encouraging discovery learning, whose advantages are: increment in intellectual potency; emphasis placed on intrinsic rather than extrinsic rewards; students masters the methods of "how" to discover; student is more likely to remember information.

Education: the act or process of imparting or acquiring general knowledge and of developing powers or reasoning and judgment.

Evaluation: While measurement only identifies amount, evaluation lays amounts against criteria so that we may make value judgments about the observed amounts.
Knowledge: acquaintance with facts and truths or principles and familiarity with a particular subject or branch of learning; gained through study, sight, and/or experience.

Learning: knowledge acquired by systematic study.

Learning Methodology: a systematic process for creating an efficient and effective learning environment which enables a training audience to develop the competencies necessary to perform their required tasks.

Measurement: the process of using numbers to describe quantity, quality, or frequency according to a set of rules.

Skill: ability to do something well through, talent, training, or practice; learned performance required to complete a task

Task: a logical and necessary step in the performance of a duty—usually a fairly long and complex procedure.

Task analysis: identification of the behavioral characteristics of a job requirement

Test: a systematic procedure for comparing the performance of an individual with a designated standard of performance.

Training: the act of making someone proficient by instruction and practice

SELECTED BIBLIOGRAHY

Learning Organizations, eds. Sarita Chawla and John Renesch. Productivity Press. 1995

"Renovating and Refurbishing the Field Experience Structures for Novice Teachers," Mary E. Little and Suzanne M. Robinson, Journal of Learning Disabilities. 07-01-1997.

"Understanding Organizations as Learning Systems," Edwin Nevis, Anthony Dibella, and Janet Gould, Sloan Management Review, 12-22-1995.

"Organizational Evolution, Learning, and Selection: A Genetic-Algorithm-Based Model," Erhard Bruderer and Jitendra Singh. Academy of Management Journal. 10-01-1996.

"The Content and Nature of reflective Teaching," Mahnaz Moallem, The Clearing House. 01-11-1997.

"Learning Organizations Evolve in New Directions," Dominic Bencivenga, Society of Human Resource Management. 1995.

"Mental Time Travel and the Evolution of the Human Mind," Thomas Suddendorff and Michael Carballis, Genetic, Social and General Psychology Monograms. 05-01-1997.

"Scenario Planning: A Tool for Strategic Thinking," Paul Shoemaker, Sloan Management Review. 01-01-1995.

"Organization-motivated Aggression: A Research Framework," Anne O'Leary-Kelly, Ricky Griffin, and David Glew, Academy of Management Review. 01-01-1996.

"The Measurement of Success Integrated Thematic Instruction," The Clearing House. 11-21-1997.

"Taking the Chaos Out Of Cooperative Learning," Kathern Thomas and Juliann Taymans, The Clearing House. 11-21-1996.

"Developing Organizational Memory Through Learning History," George Roth and Art Kleiner, Organizational Dynamics. 10-01-1998.

"STOW Network Technologies and Operational Lessons Learned," Ray Cole, Barth Root, Larry O'Farrall, LTC Paul Myers and Julie Tarr.

"Synthetic Lessons Learned from the STOW 97 ACTD," CDR Peggy Feldmann, Peter Muller, and Steve Kasputis.

"Its Time to Change Our Minds: An Invitation to Transformation Learning," Elias Dean. ReVision. 06-22-1997.

"Preparing Principals for Leadership in Special Education," Mark B. Goor, John O. Schwenn and Lynn Boyer, Intervention in School & Clinic. 01-01-1997.

"Inclusion, One step at a Time: A Case Study of Communication and Decision Making Across Program Boundaries," Dale Borman Fink and Susan A. Fowler. Topics In Early Childhood Special Education, 10-15-1997.

"Collaboration and School Reform: A Twenty-First-Century Perspective," Dorothy J. O'Shea and Lawerence O'Shea, Journal Of Learning Disabilities, 07-01-1997.

"The Executive as Coach," James Waldroop. Harvard Business Review. 11-01-1996.

"Learning to Learn," Dorothy Ettling and Neomi Hayes. ReVision. 0602201997.

"Transformation Learning In Action a Case Study (Transformation Learning)," Elizabeth Kasl and Dean Elias. ReVision. 06-22-1997.

"Enhancing Teamwork in Complex Environments Through Team Training," Renee J. Stout, Edwardo Salas, Jennefer Folwes. Journal of Group Psychotherapy. Psychodrama and Sociometry. 12-22-1997, pp163.

Perspectives on Environmental Action: Reflection and revision Through Practical Experience, Katharine M. Emmons, and Journal of Environmental Education .10-15-97.

"An Experimental Evaluation of a Cognitive-Experiential Learning Methodology in the Basic Management Course," J. Duane Hoover and Carlton J. Whitehead. Journal of Experiential Learning and Simulation 1. Pp. 119-125, 1979

Measurement for Educational Evaluation, Clinton I. Chase. Addison Wesley. 1978

Instructional Systems Development for Vocational and Technical Training. F. Coit Butler. Educational Technology Publications. 1972.

Fundamentals of Cognitive Psychology. Henry C. Ellis and R. Reed Hunt. WCB Brown and Benchmark Publishers. 1993.

Teaching for Learning: Applying Educational Psychology in the Classroom. Myron H. Dembo. Goodyear Publishing. 1977.

"Retention: The Real Power of Simulation/Gaming?" Glenn S. Pate and John A. Mateja. Journal of Experiential Learning and Simulation 1. 195-202 . 1979.

Building the Learning Organization. Michael J. Marquardt. McGraw Hill, 1996.

"Cross-national alliances and inter-organizational learning." Nanette S. Levinson and Minoru Asahi. Vol. 24, Organizational Dynamics, 09-01-1995, pp. 50(14).

Driving Change. Jerry Y. Wind and Jeremy Main. The Free Press, 1998.

"First things first: clarifying intention. (Educational Assessment: Local and National Changes). Pat Hinchey, Vol. 68, The Clearing House, 03-13-1995, pp. 253(4).

Intellectual Capital: The New Wealth of Organizations. Thomas A. Stewart. Currency/Doubleday, 1997.

"Interdisciplinary and integrative learning: an imperative for adult education." Ian Dinmore. Vol. 117, Education, 03-22-1997, pp. 452(16).

"Learning from experience through reflection." Mary Wood Daudelin. Vol. 24, Organizational Dynamics, 01-01-1996, pp. 36(13).

"Learning how to learn: the key to CQI. (quality management)." Irwin Rubin, Vol. 22, Physician Executive, 10-01-1996, pp. 22(6).

Learning Organizations. Eds., Sarita Chawla and John Renesch. Productivity Press, 1995.

"Learning Organizations come alive." Martha A. Gephart and Victoria J. Marsick, et al. Vol. 50, Training & Development, 12-01-1996, pp. 34.

"Learning Theory and the Preservice Teacher," Curt A. L. Szuberla, Vol. 117, Education 03-22-1997, pp. 381(5).

"MacGregor: an Organizational Dynamics classic revisited. (delegation of authority)." Arthur Elliott Carlisle. Vol. 24, Organizational Dynamics, 09-01-1995, pp. 65(3).

"Navigating the bumpy road to student-centered instruction." Richard M. Felder and Rebecca Brent. Vol.44, College Teaching, 04-01-1996, pp. 43.

"John Dewey as Environmental Educator," Dennis Lawrence and Douglas Kapp, Journal of Environmental Education. 01-05-1997.

"John Dewey, A voice that still speaks to us," Carole Barnett, Organizational Learning. 1998.

"A Conversation With Chris Argyris, the Father of Organizational Learning," Robert Fuller and J. Bernard Keys, Organizational Dynamics. 10-01-1997.

"Trust and Distrust: New Relationships and Realities," Roy Lewicki, Daniel McAllister, Robert Bias, Academy of Management Review. 07-01-1998.

"The Discipline of Teams: The Control of Team-Based Industrial Work Through Electronic and Peer Surveillance," Graham Sewell, Administrative Science Quarterly. 06-01-1998.

"Don't Abdicate: Teams effectiveness starts and ends at the top," Mark Frohman and Perry Pascarella, Industry Week. 11-06-1995.

"The Teacher as a Reflective Professional," Amber Dahlin," College Teaching. 04-01-1994.

"Innovative Teaching: Teaching at its Best," James Fatt, Education. 06-22-1998.

"Reflection and Teaching: The challenge of thinking beyond doing," Peggy Raines and Linda Shadiow, The Clearing House. 05-15-1995.

"Teaching Critical Thinking Skills," Nadia Bugg, Radiologic Technology. 05-15-1997.

"Individual Growth and Team Enhancement: Moving toward a new model of career development," Mary Cianni and Donna Wnuck, Academy of Management Executive. 02-01-1997.

"The Killer Angels: A case study of historical fiction in social studies curriculum," Edwin Bilof, The Social Studies. 01-11-1996.

"The Second Generation Learning Organization: New Tools for Sustaining," Robert Fulmer, Organizational Dynamics. 10-01-1998.

BIG THIKERS: Mr. LEARNING ORGANIZATION (Peter Senge)," Brian Dumaine, Fortune. 10-17-1994.

It's a Defining Principle of the new Economy: Winning Companies are Smart Companies,"

"Networking Your Knowledge," Daniel R. Tobin, Vol. 87, Management Review, 04-01-1998.

"Schools/Community Partnerships and Educational Reform." Wayne Sailor, Thomas M. Skrtic. Vol. 17, Remedial & Special Education, 09-01-1996, pp. 267.

"Social constructivist theory and principles of inclusion: Challenges for early childhood…" Bruce L. Mallory and Rebecca S. New. Vol. 28, Journal of Special Education, 09-01-1994, pp. 322.

The Circle of Innovation. Tom Peters. Alfred A. Knopf, 1997

"The effects of experience and the firm's environment on manager's project selection decisions." Jack M. Ruhl, Larry M. Parker. Vol. 6, Journal of Managerial Issues, 09-22-1994, pp.331 (19).

The Fifth Discipline. Peter M. Senge. Currency Doubleday, 1990.

The Fifth Discipline Fieldbook. P. Senge, R. Ross., B. Smith, C. Roberts, A. Kleiner. Currency/Doubleday, 1994.

The New Organizational Wealth: Managing & Measuring Knowledge-Based Assets. Karl Erik Svelby. Berret-Koehler Publishers, Inc., 1997.

"The Knowledge-Creating Company: How Japanese Companies Create the Dynamics of Innovation." Mary M. Crossan. Vol. 27, Journal of International Business Studies, 03-01-1996, pp. 196(6).

"The measurement, use, and development of intellectual capital to increase public sector productivity." Weston H. Agor. Vol. 26, Public Personnel Management, 06-22-1997, pp. 175(12).

"The quest to translate research into classroom practice," Russell Gersten and Susan Unok Brengelman. Vol. 17, Remedial & Special Education, 03-01-1996, pp67.

"Using active learning as assessment in the postsecondary classroom. (Forms and Functions of Formative Assessment," Charles C. Bonwell, Vol. 71, The Clearing House, 11-21-1997, pp73(4).

"Who should taste the soup and when? Designing portfolio assessment programs to enhance learning." (Forms and Functions of Formative Assessment). Sandra M. Murphy, Vol. 71, The Clearing House, 11-21-1997, pp. 81(4).

"Who will be learning disabled after the reauthorization of IDEA? Two very distinct perspectives." Martha J. Coutinho. Vol. 28, Journal of Learning Disabilities, 12-01-1995, pp. 664.

"Test, Training and Performance Monitoring Study," James Brewer, US Navy. 1989.

"Tactical Training Strategy," US Navy. 1993.