ESTABLISHING A LEARNING ENVIRONMENT FOR JSIMS: CHALLENGES AND CONSIDERATIONS

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The Joint Simulation System (JSIMS) is comprised of modeling and simulation technologies that represent the next generation of large-scale training systems. One goal of JSIMS is to provide enhanced capabilities for planning, preparing, executing, and evaluating training across a variety of audiences (e.g., Joint Task Force, Multi-Service, and Single-Service). JSIMS will provide appropriate representations of strategic, tactical, and operational environments. While this synthetic environment holds considerable promise for conducting training, models and simulations by themselves will not result in effective learning environments. Effective learning environments result when appropriate learning strategies, tools, and methods are integrated with technologies to support training.

While detailed processes exist for development of synthetic environments, similar methods for establishing effective learning environments are only beginning to emerge. One method with considerable promise for JSIMS is known as the Event-Based Approach to Training (EBAT). EBAT provides a systematic approach for developing learning objectives, generating scenarios, measuring performance, and providing feedback. EBAT has been successfully used in a number of settings to establish effective learning environments which have in turn, resulted in improved performance. EBAT provides a basis for developing a learning environment for JSIMS and supports the requirements of the Joint Training System (JTS).

This paper will (a) provide an overview of JSIMS, (b) present a conceptual model of a learning environment, (c) describe JSIMS in terms of the conceptual model, (d) identify the major challenges and considerations for establishing a JSIMS learning environment, and (e) discuss the implications of the framework for other training systems and required research and development efforts.

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INTRODUCTION

The Gulf War and recent peace-keeping operations have provided previews of what future military missions will involve. Mission-specific Joint Task Forces (JTFs) composed of military personnel from different services and different nations will be the norm (Meadows, 1995). The success of these task forces will be contingent upon preparedness. As part of this preparedness, training at the JTF level has been identified by the Chairman of the Joint Chiefs of Staff as an issue for immediate action (CJCSI 3500.02A, 1995). Currently, resource intensive exercises provide the only method for JTFs to practice.

Technological advances have begun to emerge that have considerable potential for creating virtual training environments (Bell, 1996). These environments use modeling, simulation, and networking to create common and shared battlespaces that imitate conditions representative of military operations. The Joint Simulation System (JSIMS) is one example of a large scale modeling and simulation system that makes extensive use of recent technological advances. JSIMS is expected to provide enhanced training capabilities while significantly reducing the resources required to conduct training.

Despite the tremendous potential that systems like JSIMS can provide for training, few guidelines and principles exist regarding how to best design and use these systems to establish effective learning environments (Salas, Bowers, & Cannon-Bowers, 1995). Effective learning environments require appropriate methods, strategies, and tools that facilitate the acquisition and retention skills given the required competencies of the training audience (Cannon-Bowers and Salas, 1997).

Unfortunately, little is known about (a) what components of these large scale training systems (e.g., audience characteristics, task requirements, training environment) will impact efforts to establish an effective learning environment, or (b) what learning strategies, methods, and tools have applicability in these environments. Because little is known about these factors, ensuring that effective learning environments exist in these large scale training systems like JSIMS will be a difficult task (Dwyer, Fowlkes, Oser, Salas, and Lane, 1997).

The goal of this paper is to provide a framework for understanding and establishing a JSIMS learning environment. Specifically, the paper will (a) provide an overview of JSIMS, (b) present a conceptual model of a learning environment, (c) describe JSIMS in terms of the conceptual model, (d) identify the major challenges and considerations for establishing a JSIMS learning environment, and (e) discuss the implications of the framework for other large scale training systems and required research and development efforts.

JSIMS

JSIMS represents the next generation of large scale modeling and simulation systems. JSIMS is comprised of a core infrastructure and a set of mission space models maintained in a common repository (Pratt, 1997). The models and simulations provide an integrated environment that can be composed to support a range of joint-service or service-specific applications which will include training, mission rehearsal, doctrine development, education, and analysis (Operational Requirements Document for JSIMS, 1996).

In general, the development of JSIMS will be accomplished in two major phases. The first phase is referred to as the Initial Operational Capability (IOC). At IOC, JSIMS will replace and enhance the functionality and fidelity of the currently existing Joint Training Confederation (JTC) for JTF training. Additionally, JSIMS at IOC will significantly reduce the resources required for exercise support and enable users to train using real-world Command, Control, Communication, Computer, and Intelligence (C4I) systems.

The second phase of development is referred to as the Final Operational Capability (FOC). At FOC, the functionality of JSIMS will be significantly expanded as compared to IOC to support training at the platform level, development of new doctrine and tactics, mission rehearsal, linkages to additional models, and a wider range of military operations (e.g., operations other than war).

A CONCEPTUAL MODEL OF THE LEARNING ENVIRONMENT

Considerable advancements have been made in the areas of modeling, simulation, and networking technologies. While these advancements have resulted in processes that can be used to develop environments with the potential for training, few efforts have focused on how to best use these systems to establish effective environments to support learning (Dwyer, et al., 1997). As a result, it is possible that the modeling and simulation systems may not adequately achieve their intended objectives.

Effective learning environments are systems that enable a training audience to develop the competencies necessary to perform required tasks. Effective learning environments require the implementation of appropriate learning strategies, methods, and tools as a function of the training audience, the task requirements, and the training environment. Learning strategies, methods, and tools need to support (a) all phases of training development (e.g., planning, preparation, execution, analysis), (b) performance measurement, and (c) feedback. One way to conceptualize a learning environment can be found in Figure 1. Because of the relationship between these components, the next section will briefly describe each component of the learning environment model in more detail.

Training Audience

Clearly, the training audience is at the center of the learning environment model. The training audience is the primary reason that a learning environment is required. Most complex tasks require the coordination of multiple individuals for effective performance (Salas, et al., 1995). Depending on the characteristics of the task, the requirement for multiple individuals can range from small teams, such as aviation aircrews, to JTFs comprised of over a thousand individuals organized into numerous sub-teams.

Team characteristic factors that need to be considered when establishing a learning environment include (a) the extent to which the members of the team possess shared understanding and expectations (Cannon-Bowers, Salas, & Converse, 1993), (b) the manner in which the team is organized (Urban, Bowers, Monday, & Morgan, 1995), and (c) the degree to which the team is located in the same physical environment (Dwyer et al., 1997). These factors will impact what tasks need to be trained and how the tasks must be trained.

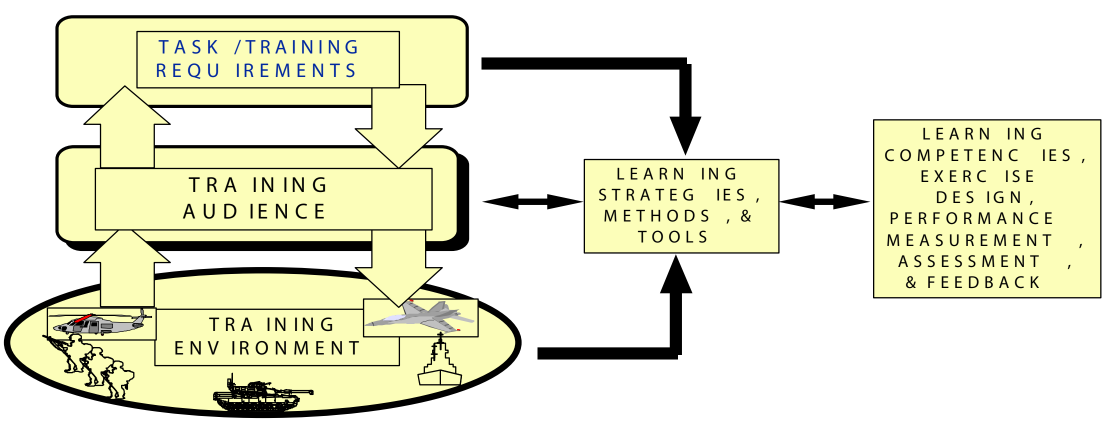

Figure 1. A Conceptual Model of a Learning Environment

Task Requirements

Although the characteristics of the training audience are important, the requirements of the tasks to be performed by the training audience must also be understood (Salas & Cannon-Bowers, 1997). Two important task characteristics include (a) the information requirements of the task and (b) the length of the task. The information requirements of tasks can range from tasks that require limited information from few sources (e.g., psychomotor, procedural) to tasks that require information from a variety of disparate sources (e.g., situation assessment, resources management, planning).

The length of the task refers to the extent to which the task focuses on immediate or future actions. Tasks that are oriented to immediate actions require rapid, and often automatic, responses. These responses will generally result in instantaneous feedback about performance. In comparison, tasks that involve future actions require the development of longer term strategies and plans. Strategy development and planning can rarely be accomplished using rapid and automatic responses. Feedback from tasks oriented to future actions is often delayed until the strategy or plan is actually implemented.

Training Environment

Given the characteristics of the training audience and task requirements, the nature of the training environment must also be considered during the development of a learning environment (Dwyer et al., 1997). Characteristics of the training environment include (a) the frequency of training opportunities (i.e., how often the training occurs), (b) the length of the training cycle (i.e., how much time transpires between the initiation and completion of the training), (c) the extent to which the training environment simulates the real world (i.e., is the environment realistic and believable), and (d) the location of the training (i.e., is the training conducted in one location or across multiple locations).

Depending on these factors, learning environments are likely to require different strategies, methods, and tools. Using the frequency of training as an example, training audiences that have numerous opportunities to train can be presented with numerous repetitions of the same scenario or similar scenarios until proficiency is achieved. In comparison, use of repetition for training audiences that have few training opportunities may be impractical. The factors associated with the training environment need to be understood in order to determine what can actually be trained in the learning environment.

Learning Strategies, Methods, and Tools

Given the characteristics of the training audience, task requirements, and training environment, steps toward development of an effective learning environment can be initiated. The establishment of an effective learning environment must be considered in terms of a number of conceptual premises (Salas & Cannon-Bowers, 1997). An understanding of these premises is required prior to the identification, selection, and implementation of learning strategies, methods, and tools.

Technology Alone does not Guarantee Effective Learning. Learning environments must be viewed as a system of several inter-related components. Each component must be understood to optimize the potential that learning will occur. While advancements in training technology hold great promise, technology is only a part of effective learning environments. Technology must be appropriately applied as a function of the training audience, task requirements, and training environment. Furthermore, the technologies must support the necessary learning and performance measurement methods, strategies, and tools.

Learning is a Cognitive and Behavioral Process. Learning must be viewed as a cognitive and behavioral process. The missions and tasks to be trained are often very complex and situationally dependent. Effective performance requires competencies in a wide range of knowledge, skills, and abilities including strategic planning, situation assessment, decision making, and resource management. Often, performance is further complicated because there may be few procedures and more than one approach to successfully accomplish a mission. Because of these issues, training needs to focus on providing participants with the necessary knowledge (i.e., cognitions) and skills (i.e., behaviors) required to perform these difficult tasks.

A Systematic Approach to Learning will Facilitate Skill Acquisition and Retention. Learning environments must employ systematic, deliberate approaches to achieve critical task requirements of the training audience. These approaches need to include appropriate learning and measurement methods, strategies, and tools. Free play is not a viable training strategy for most situations because it often leaves opportunities to train and receive feedback on critical competencies to chance (Cannon-Bowers & Salas, 1997).

Systematic approaches to training require the presence of specific, pre-planned opportunities for the training audience to demonstrate and receive feedback in critical competencies. The deliberate introduction of these opportunities must be transparent and believable to the training audience. Otherwise, the training audience may not perform in a realistic manner.

Performance must be Systematically Measured. Effective learning environments employ a multi-faceted approach to measuring performance and providing feedback (Johnston, Smith-Jentsch, & Cannon-Bowers, 1997). Based on a systematic assessment of performance, feedback can be effectively designed and provided such that performance can be improved. Without effective performance measurement and feedback, there is no way of knowing or ensuring--with any degree of certainty--that the training will have its intended effect.

Measures must allow the systematic assessment of performance (i.e., proficiencies and deficiencies) associated with critical tasks and competencies. Depending on the specific characteristics of the learning environment, a variety of measurement approaches may be required. For example, the measurement of competencies that are unique to a single task, given a specific set of conditions (e.g., perform a specific peacekeeping mission in XYZ country that possesses ABC weapons capabilities), will vary from the measurement of competencies that can generalize across a variety of tasks and conditions (e.g., perform strategic planning, situation assessment, and decision making).

An important characteristic of the multi-faceted approach to measurement requires the collection of data involving outcomes (e.g., was the right decision made?) and processes (e.g., was the decision made right?) (Johnston et al., 1997, Dwyer et al., 1997). While outcome measures do provide important information regarding overall performance, process measures are required for diagnosing specific deficiencies associated with how a given outcome was reached.

Training for Complex Environments Requires an Event-Based Approach. One framework that provides the mechanisms to facilitate the creation of a learning environment is the Event-Based Approach to Training (EBAT). EBAT is a framework based on the systematic structuring of learning opportunities using appropriate learning methods, strategies, and tools. EBAT ensures that learning occurs in an efficient and thorough manner by tightly linking critical tasks, learning objectives, exercise design and execution, performance measurement, and feedback. (Salas and Cannon-Bowers, 1997; Dwyer et al., 1997). A more detailed description of EBAT is provided in a following section.

CREATING A LEARNING ENVIRONMENT FOR JSIMS

Although JSIMS is envisioned to provide a wide variety of capabilities for many applications and to support a range of users, the current effort will only emphasize those capabilities expected to be present at IOC (i.e., JTF training). The conceptual model of the learning environment has implications for supporting JTF training via JSIMS. Therefore, the following section describes the components of the learning environment model with respect to the nature of JTFs.

Training Audience

One important characteristic of JTFs is their multi-service composition. Clearly, this composition has the potential to enhance performance because of the diversity and resources that each service can bring towards achieving a military objective. However, these differences also present challenges for JTFs with regard to coordinating their activities. While each service brings unique expertise to the JTF, members from one service may not possess the basic knowledge about the other services required to develop the shared understanding necessary to anticipate the information requirements of the other members. Despite recent progress to minimize the differences between the services with respect to doctrine, procedures, and terminology, differences are still present. The challenge to effective coordination is further complicated when JTFs include personnel from coalition countries with different cultures.

A second important characteristic is the complexity of the JTF organizational structure. JTFs are comprised of staff members that range from a JTF Commander, who has the overall responsibility for the operation, to numerous enlisted personnel each responsible for critical tasks in support of the operation. This type of structure presents considerable challenges for the exchange of information throughout the highly differentiated organization. Clearly, the information required by the JTF Commander is different than that required by enlisted personnel. While JTFs are comprised of teams of teams that are hierarchically organized, changes in the tactical situation may require modifications to the organization. As a result, JTFs must be capable of adapting their organizations to respond to changing situational conditions in a coordinated manner.

Because of the size of JTFs, it is impossible for all members of the team to be physically co-located even if they are stationed at the same facility. Recent advances in networking technologies have provided capabilities that enable JTFs to operate in these geographically distributed environments. The distribution often requires that communication and coordination takes place via electronically mediated means. A challenge for JTFs is to optimize the efficiency of the interactions via appropriate technologies that support effective coordination despite being geographically separated.

Task Requirements

JTFs are responsible for a wide variety of complex tasks involving C4I functions. These tasks involve decision making, resource management, and situation assessment. JTFs must be capable of accessing a considerable amount of information from a variety of sources. JTFs must effectively perform despite information that may be incomplete, ambiguous, contradictory, or inaccurate. A challenge for JTFs is to coordinate the synthesis of the information such that the tactical situation can be accurately assessed.

Using information from C4I sources, the JTFs develop strategies and plans to meet operational objectives over a specific period of time. The goal of the strategies and plans is to ensure that the right resources are at the proper location at the required time. Poor strategies and plans have the potential to result in ineffective management and resource allocation. Often, strategies and plans may cover lengthy time periods (i.e., days, weeks, months). As a result, the effectiveness of a strategy or plan may not be known until a considerable amount of time has elapsed. This limits the ability of the JTFs to receive immediate feedback for the purpose of changing the plans and strategies. Furthermore, although JTFs must focus on performance over extended periods of time, real-time changes in the operational environment must also be synthesized into new strategies and plans.

Training Environment

JTF training opportunities may be infrequent. Because of the numerous operational requirements placed upon JTFs, opportunities for these organizations to train in full complements of the various component commands do not frequently occur. For example, JTFs may train in this configuration less than one time per year. The limited number of training trials has implications for the retention of skills. When JTFs do have an opportunity to train, the training may occur in multiple phases over several months. Often, each phase will have a different focus (e.g., academics, planning, execution). An exercise in a given phase often lasts several days. These factors have implications for the retention of the knowledge and expertise. For example, knowledge acquired during one phase of training may not be retained for a following phase because of other activities that have taken place.

Because of recent advances in networking technologies, it is now possible for JTFs to train together despite being in separate locations. While these networks provide capabilities that were previously unavailable, the distributed nature of these environments introduces a number of challenges for training. Specifically, performance measurement, exercise management and control, and presenting feedback are particularly challenging in distributed environments (Fowlkes, Lane, Dwyer, Willis, & Oser, 1995). Guidelines do not currently exist to support (a) aggregating performance measures obtained for participants at different locations, (b) developing scenarios that will provide meaningful training events for distributed training audiences, and (c) generating and presenting feedback to distributed training audiences in a timely manner.

Learning Strategies, Methods, and Tools

Unfortunately, few approaches exist to guide the development of JTF learning environments given the requirements of the training audience, task, and training environment. That is, little is known about appropriate learning strategies, methods, and tools or about performance measurement, assessment, and feedback for JTFs. One approach that has potential to guide the development of a JSIMS learning environment is EBAT. The components of EBAT are shown in Figure 2. The following section will briefly describe the components of EBAT.

Components of EBAT. EBAT begins with the specification of learning objectives associated with mission tasks, conditions, and standards. Depending on the training audience and task requirements, learning objectives can be associated with a specific task (e.g., demonstrate the ability to perform task XYZ) or general competencies required across a number of tasks (e.g., situation awareness, decision making, resource management, planning, communication).

The approach then requires that "trigger events" be either identified or developed for each learning objective. The events create specific opportunities for the participants to practice critical tasks and competencies associated with learning objectives. The events allow the participants to demonstrate their proficiencies and deficiencies for the purpose of performance measurement and feedback. Typically, a number of events are created for each learning objective that (a) vary in difficulty and (b) occur at different points of an exercise.

The EBAT methodology then involves the development of performance measures to collect data associated with the events. Within this context, the measurement tools enable the (a) examination of performance trends during the exercise and (b) development of diagnostic performance feedback. Measuring performance at several events for a specific learning objective enables the development of profiles of how well a team performs on that objective over a range of conditions.

Given the task requirements, learning objectives, events, and performance measures, a scenario is then developed. Scenarios must permit the training audience to interact in realistic situations that will facilitate learning. 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 utilization of the performance measures for feedback.

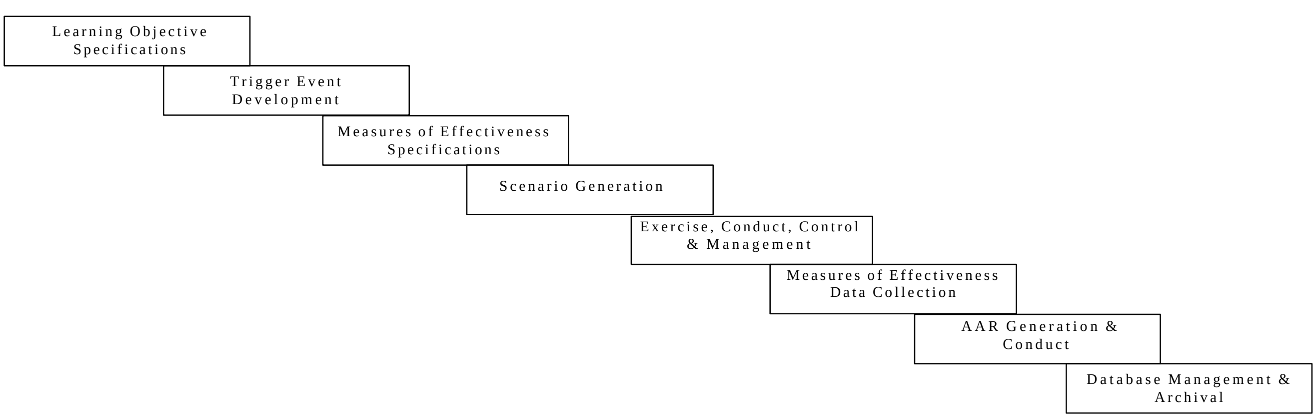

Figure 2. Components of the Event-Based Approach to Training

After the scenario is generated and tested, the audience can interact with the training environment. Obviously, exercise management and control of exercise flow are critical aspects of this process. While training participants must be permitted to make their own decisions and fight the simulated battle in a manner consistent with doctrine, exercise managers must ensure that the right types of opportunities are presented--in a controlled manner--to meet the intended objectives.

The participants perform the scenario and measurement data are collected to support feedback. Specifically, when an event occurs, performance related to that event is assessed. Performance is documented, analyzed, and packaged to highlight critical teaching points for subsequent feedback. The systematic linkage continues by tying feedback topics to the performance measures, which in turn are linked to the events and learning objectives. This approach provides structure and control to training and ensures internal consistency throughout an exercise.

Following the completion of the exercise, appropriate data are stored and archived in a meaningful manner that supports the development of lessons learned and future exercises. Data collected across exercises can facilitate the development of normative databases. As data accumulate and archives grow, normative patterns will emerge and performance for a given team can be compared against the "norm."

In summary, because of the linkages in EBAT, performance can be traced directly back to specific learning objectives via events and performance measures. Performance related to a given objective can then be assessed and fed back to the training audience. The linkages are critical, and therefore must not be viewed as a set of options. If properly implemented, EBAT has the potential to establish an effective learning environment for JSIMS.

EBAT and JSIMS. EBAT has considerable potential for establishing an effective JSIMS learning environment for a number of reasons (Oser, Cannon-Bowers, Dwyer, & Miller, 1997). First, EBAT supports the development of a JSIMS learning environment by complying with recent efforts conducted to define the Joint Training System (Oser et al., 1997). JTS is a Joint-Service initiative that structures the planning, preparation, execution, and assessment of JTF training (CJCSI 3500. 02A, 1995). Specifically, EBAT (a) supports all phases of the Joint Exercise Life Cycle (JELC) (i.e., planning, preparing, executing, and evaluating exercises), (b) can provide learning objectives from the Universal Joint Task List (UJTL) and the results of the Joint Mission Essential Task List (JMETL) development process (see Figure 3), and (c) extends the UJTL/JMETL development process by providing mechanisms to develop effective process and outcome measures for feedback purposes.

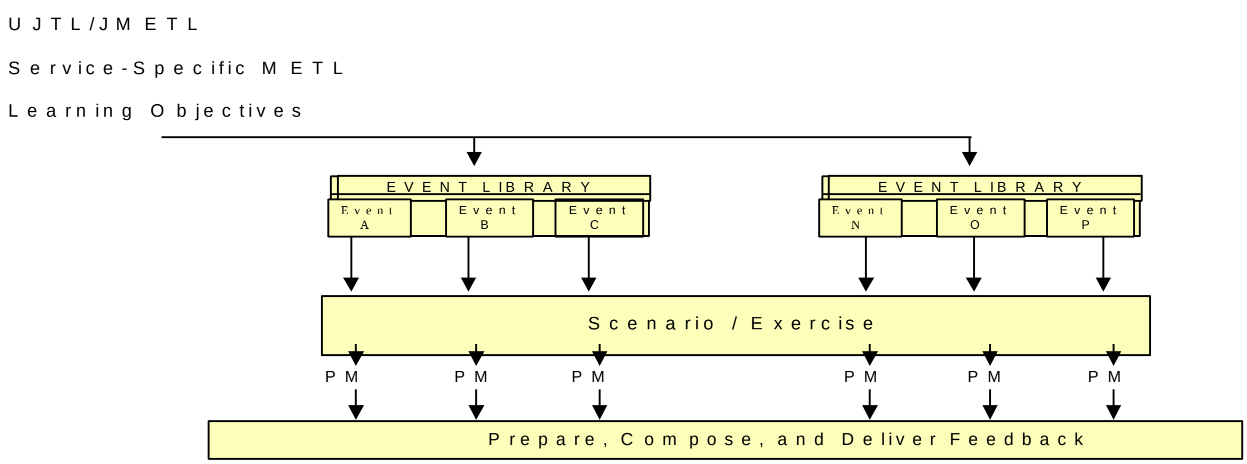

Figure 3. Conceptual Flow between Universal Joint Task List and an Event-Based Approach for Training

Second, learning environments with components of EBAT have resulted in psychometrically sound measures and improved performance across a variety of training audiences, task requirements, and training environments (e.g., Combat Information Centers - Johnston et al., 1997; Military Aircrew Coordination Training - Fowlkes, Lane, Salas, Franz, & Oser, 1994; Multi-Service Distributed teams - Dwyer, Oser, & Fowlkes, 1995).

Third, EBAT can also provide relevant input for the design of the JSIMS system architecture and software (Oser et al., 1997). For example, performance measurement, data collection, and data reduction can require a considerable amount of system processing and bandwidth resources. Decisions about what actually needs to be collected and analyzed can be supported by using EBAT to systematically provide linkages between these components.

ESTABLISHING AN EBAT LEARNING ENVIRONMENT FOR JSIMS - CHALLENGES AND CONSIDERATIONS

Clearly, establishing an effective JSIMS learning environment is a challenging task given the characteristics of the JTF training audience, task requirements, and training environment. In an effort to meet the challenges, the following considerations are forwarded:

(a) use a conceptual model of a learning environment as a framework to identify and organize critical factors that will impact learning;

(b) use EBAT as a set of learning strategies, methods, and tools for establishing a learning environment for JSIMS;

(c) use learning strategies, methods, and tools that provide systematic linkages among learning objectives, scenario development, performance measurement, and feedback;

(d) use a systematic approach to identify those competencies that must be trained and can be trained in a JSIMS environment;

(e) use a multi-faceted approach for performance measurement (e.g., outcome, process, objective, subjective, individual, and team) to support feedback;

(f) use realistic scenarios that include pre-defined events which provide specific opportunities for the training audience to demonstrate proficiencies and deficiencies related to learning objectives; and

(g) use scenario control and management techniques that are transparent to the training audience and do not restrict the decisions that can be made by the training audience.

CONCLUSION

Use of systems like JSIMS will become more pronounced in the future. In many military applications, it will be the training environment of choice. While continued engineering is important, technological developments will not be enough. Additional work in the development of learning strategies, methods, and tools--such as those offered through EBAT--must be pursued and applied if we expect to maximize training resources.

Work remains to further identify effective strategies for establishing learning, developing exercises, measuring performance, and providing feedback for systems like JSIMS. Other improvements could be achieved through effective design of the models, simulations, and networks themselves. Efforts in these areas will be an important step towards the development of effective learning environments.

While the current focus has been on JTF training, JSIMS is envisioned to provide capabilities for a wide range of applications and users. As capabilities of JSIMS are expanded, a re-examination of the learning environment characteristics will be required to ensure that appropriate methods, strategies, and tools are developed and implemented.

In summary, systems like JSIMS have considerable potential for training, however models and simulations by themselves will not result in effective learning environments. Effective learning environments require the integration of technologies with learning strategies, tools, and methods.

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