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THEORETICAL FOUNDATION FOR ADVANCED DISTRIBUTED LEARNING RESEARCH

MAY 2001

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13. ABSTRACT (*Maximum 200 words*)
Advanced Distributed Learning (ADL) has been embraced by the Department of Defense, other Government agencies, private industry, and academia as a tool that has the potential to improve the efficiency and effectiveness of modern instructional systems. As with any other instructional approach, ADL cannot achieve its full potential if the individuals and organizations involved in its development fail to understand that ADL systems are controlled and constrained by system principles. The goal of this paper is to sensitize individuals working in all aspects of ADL systems to the power of a system view and to provide several examples of system methods and tools. The paper presents a theoretical foundation for an ADL research agenda based upon an overview of system concepts and discussion of how they apply to the development and implementation of ADL systems. It argues that the adoption of a system perspective will improve the communication and understanding among the diverse groups engaged in ADL system development and can help ADL mature into an effective instructional alternative. A number of ADL research issues are discussed and several system-oriented methodologies are suggested to address these issues.

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EXECUTIVE SUMMARY

PROBLEM

The Department of Defense (DoD), other Government agencies, academia, and private industry are required to provide education and training on an increasingly varied and complex range of tasks and skills, with a dwindling amount of resources. To meet this challenge, the DoD and the White House Office of Science and Technology Policy (OSTP) launched the Advanced Distributed Learning (ADL) Initiative in November 1997. The goal of the ADL Initiative is to ensure access to high quality education and training materials that can be tailored to individual learner needs and made available whenever and wherever they are required

OBJECTIVE

This objective of this report is to provide a theory-based ADL research agenda. This research agenda must identify critical research areas and issues to be explored if the goals of the ADL Initiative are to be achieved. Furthermore, within each research area, methods and techniques must be identified that will efficiently generate the data required to achieve these goals.

APPROACH

An overview of system concepts and methods is applied to identify and discuss critical ADL research areas and issues. Moreover, these system concepts are used to argue that a system perspective can be beneficially applied to ADL system development. The adoption of a system perspective leads individuals to focus on the complex interactions between and among the many varied systems, which affect the evolution of ADL capabilities. System theory-based tools and methods are identified for each research area.

RESULTS

Five system considerations (Churchman, 1968) were used to discuss ADL from a system perspective. These considerations are: understand the total ADL system objectives, understand the ADL system's environment, understand the resources available, understand the ADL subsystem components, and understand the management of the ADL system. Several research areas are discussed: application of system concepts and approaches to ADL, cross-level generalizations, identification of system relationships, ADL goals and needs analysis, ADL development guidelines, evaluation of ADL systems, and configuration management of ADL systems.

CONCLUSIONS AND RECOMMENDATIONS

Guided by a system perspective, the application of system tools and concepts can improve our ability to develop effective and economical ADL systems. Adoption of the research agenda presented in the paper is a first step in generating the data necessary to reach this goal.

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INTRODUCTION

PROBLEM

As we begin the twenty-first century, the Department of Defense, other Government agencies, academia, and private industry are required to provide education and training on an increasingly varied and complex range of tasks and skills, with a dwindling amount of resources. To meet this challenge, the Department of Defense (DoD) and the White House Office of Science and Technology Policy (OSTP) launched the Advanced Distributed Learning (ADL) Initiative in November 1997.

The goal of the ADL Initiative is to ensure access to high quality education and training materials that can be tailored to individual learner needs and made available whenever and wherever they are required. ADL has the potential for: reducing education and training costs, providing instruction on time and on demand, increasing access to instruction, increasing availability of refresher training and job performance support, and increasing the retention of learning. As part of the ADL Initiative, the Office of the Deputy Secretary of Defense (Readiness) established the ADL Co-Laboratory Network. The ADL Co-Laboratory, located in Alexandria, VA, coordinates development of common standards for ADL and promotes interagency coordination and collaboration on ADL efforts. The Joint ADL Co-Laboratory, located in Orlando, FL, develops techniques and guidance to implement ADL in the military services. The Academic Co-Laboratory, at the University of Wisconsin, Madison, WI, focuses primarily on ADL efforts in academic institutions.

The shift of even a portion of DoD education and training from traditional delivery methods to ADL is a huge undertaking. For example, there are over 190 schoolhouses under the cognizance of the Chief of Naval Education and Training (CNET). These schoolhouses provide instruction to approximately 80,000 students per year. Plans to reduce schoolhouse infrastructure require the conversion of approximately 3400 courses to some form of ADL (Slater, 2001). This is only a small portion of the ongoing ADL efforts in the military services. Similar large-scale efforts are also ongoing in academia and industry.

OBJECTIVE

The objective of this report is to provide a theoretical foundation for an ADL research agenda, which will help reduce the fragmentation often found in the development and implementation of instructional systems. Many instructional developers (e.g., Merrill, Li, & Jones, 1990) have noted that a major limitation of instructional development approaches is the failure to integrate the various phases of development and implementation. This lack of instructional system integration has been shown to compromise their effectiveness (e.g., Caro, 1977; Hritz & Purifoy, 1980; Iffland & Whiteside, 1977; Kane & Holman, 1982). On the other hand, evidence also exists that enhanced system integration can improve instructional effectiveness (e.g., Martin & Rose, 1988; Rose & Martin, 1988). As with any other instructional approach, ADL will not be optimally successful unless it achieves a higher degree of system integration. A more in-depth understanding of system concepts can help the individuals engaged in ADL research identify the critical issues that must be addressed to ensure more effective ADL instructional products.

ORGANIZATION OF THE REPORT

The remainder of the report includes four major sections. The next section provides an overview of system theory and system concepts. The following section includes a discussion of ADL systems in the context of Instructional System Development. System approaches are applied to ADL in the third section. The fourth section is a discussion of seven ADL research areas and the system tools and methods, which can be applied in each area. The report concludes with a summary and recommendations section.

OVERVIEW OF SYSTEM CONCEPTS

DEFINITION OF SYSTEMS

Systems have been defined in many different ways (e.g., Churchman, 1968; Koestler, 1969; Laszlo, 1972; Miller, 1978; Ruesch, 1969; van Gigch, 1978; Weiss, 1969; & Wright, 1989). For the purposes of this report, the following major concepts will collectively serve as our definition of systems:

1) Systems are bounded sets of **interrelated parts**, such that changes in one part will cause changes in the other parts.

2) Systems act to maintain their **internal consistency** even in the face of external changes.

3) The **emergent qualities** of a system cannot be explained by mere addition of parts; rather, relations and interactions within the system must explain these qualities.

4) Systems are always **embedded in a hierarchy of subsystems and suprasystems**, and interactions occur between system levels at all times. Every system is a component (subsystem) of a larger system. The larger system, which includes the system of interest, is called a suprasystem. A simplified depiction of this relationship is shown in Figure 1. The system

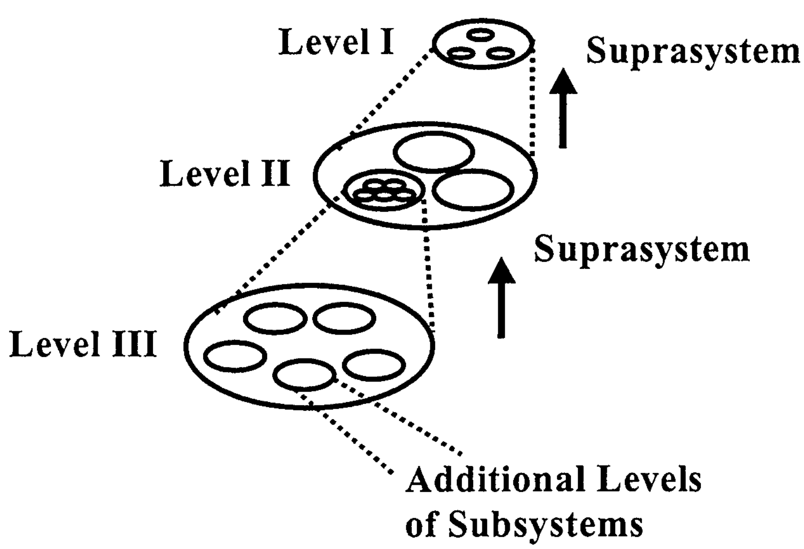

Figure 1. Relationship of Sub- and Suprasystems

shown at Level I is made up of three subsystems. A larger view of these subsystems is labeled Level II. One of these Level II systems includes five subsystems, which are shown in greater detail on Level III. Additional sub- and suprasystems could be depicted in both directions.

5) A system, when viewed from its own level, seems autonomous and it appears to exert control over its subsystems. On the other hand, when viewed from the level of the suprasystem, it appears to be under the suprasystem's control. A problem can arise when a subsystem attempts to reach a goal that is in conflict with those of its suprasystem. No matter how much effort is expended by the subsystem, the suprasystem's goals will dominate. Furthermore, some systems may be a subsystem of more than one suprasystem, as shown in Figure 2. This can cause even more problems, especially if the goals of the multiple suprasystems conflict.

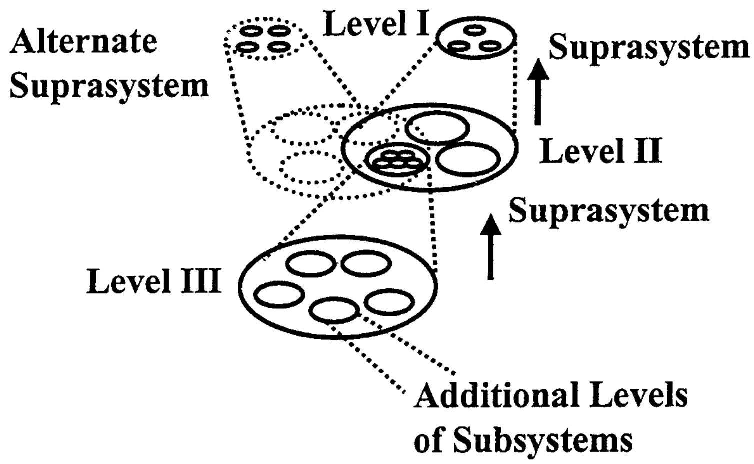

Figure 2. A Subsystem as Part of More than One Suprasystem

Hays (1992) argued that system definitions and considerations apply to training systems. This report argues that they also apply to ADL systems. In later sections, selected system concepts will be applied to the analysis of ADL systems.

SYSTEM APPROACHES

Systems have been studied since Aristotle began to examine living organisms (Gaines, 1978). Psychophysicists examine sensation and perception as interactions among various systems within the organism (Gibson, 1966). Some of the more widely known system approaches include:

• Cybernetics, which is based on the theory of communication and control and emphasizes information transfer and feedback (Wiener, 1948).

• Graph and Net theory, which focuses on the structural or topological properties of systems (Cartwright & Harary, 1956; Harary & Schwenk, 1974).

• Other system approaches, such as information theory (Shannon & Weaver, 1949), automata theory (von Neumann, 1956), and fuzzy set theory (Bellman & Zadeh, 1970).

All of these approaches share one major characteristic; they study the properties of systems, viewed as wholes, interlinked with other systems and explained by system laws. These and other system theories have been grouped under a unifying approach called General Systems Theory.

General Systems Theory

General Systems Theory (GST) arose as an interdisciplinary effort to understand the complex interactions of biological systems and subsystems (von Bertalanffy, 1968; 1969). The interdisciplinary nature of GST has fostered synergistic relationships that can advance scientific understanding.

GST is more than a set of theories. It is a paradigm shift (Kuhn, 1962) in the way one views and orders the world (Boulding, 1964; Laszlo, 1972). The system perspective prompts individuals to look beyond their own subsystem to the interactions between subsystems and suprasystems. GST is concerned with all types of systems. A branch of GST that is "concerned with a special subset of systems, the living ones, " (Miller, 1978, p. 9) is called Living Systems Theory (LST).

Living Systems Theory

LST (Miller, 1978) applies the system perspective to all living systems ranging from cells to societies. Three of the major theoretical assumptions of LST are:

1) There are **19 critical subsystem processes**, which each living system must accomplish, or have some other system accomplish for it, if it is to remain viable. Table 1 summarizes these subsystem processes. The labels for the 19 subsystem processes were specifically chosen to be general so they could: a) "be as acceptable as possible when applied at all levels and to all types of living systems" (Miller, 1978, p. 27); and b) be neutral, "not be associated exclusively with any type or level or system, with biological or social science, with any discipline, or with any particular school or theoretical point of view" (Miller, 1978, p. 27).

2) Systems at all levels (from the cell to the society) have the same 19 critical subsystems. However, at more complex levels, the **critical subsystem processes are not tied to single subsystems** in a one-to-one fashion. Rather, the functions may be dispersed among various subsystems in a process labeled "shred-out." "Each process is broken down into multiple subprocesses which are mapped upon multiple structures, each of which becomes specialized for carrying out a subprocess" (Miller, 1978, p. 26). In certain cases, via shred-out, the critical processes are dispersed to various components of the system, to components of its suprasystem, or even, to artifacts created for specific functions. For example, in a society, the distribution

Table 1

The 19 Critical Subsystems of a Living System

Subsystems Which Process Both Matter-Energy and Information	
1. **Reproducer**, the subsystem which is capable of giving rise to other systems similar to the one it is in.	
2. **Boundary**, the subsystem at the perimeter of a system that holds together the components which make up the system, protects them from environmental stresses, and excludes or permits entry to various sorts of matter-energy and information.	
Subsystems Which Process Matter-Energy	**Subsystems Which Process Information**
3. **Ingester**, the subsystem which brings matter-energy across the system boundary from the environment.	11. **Input transducer**, the sensory subsystem which brings markers bearing information into the system, changing them to other matter-energy forms suitable for transmission within it. 12. **Internal transducer**, the sensory subsystem which receives, from subsystems or components within the system, markers bearing information about significant alterations in those subsystems or components, changing them to other matter-energy forms of a sort which can be transmitted within it.
4. **Distributor**, the subsystem which carries inputs from outside the system around the system to each component.	13. **Channel and net**, the subsystem composed of a single route in physical space, or multiple interconnected routes, by which markers bearing information are transmitted to all parts of the system.
5. **Converter**, the subsystem which changes certain inputs to the system into forms more useful for the special processes of that particular system.	14. **Decoder**, the subsystem which alters the code of information input to it through the input transducer or internal transducer into a "private" code that can be used internally by the system.
6. **Producer**, the subsystem which forms stable associations that endure for significant periods among matter-energy inputs to the system or outputs from its converter, the materials synthesized being for growth, damage repair, or replacement of components of the system, or for providing energy for moving or constituting the system's outputs of products or information markers to its suprasystem.	15. **Associator**, the subsystem which carries out the first stage of the learning process, forming enduring associations among items of information in the system.
7. **Matter-energy storage**, the subsystem which retains in the system for different periods of time, deposits of various sorts of matter-energy.	16. **Memory**, the subsystem which carries out the second stage of the learning process, storing various sorts of information in the system for different periods of time. 17. **Decider**, the executive subsystem which receives information inputs from all other subsystems and transmits to them information outputs that control the entire system. 18. **Encoder**, the subsystem which alters the code of information input to it from other information processing subsystems, from a "private" code used internally by the system into a "public" code which can be interpreted by other systems in its environment.
8. **Extruder**, the subsystem which transmits matter-energy out of the system in the form or products or wastes. 9. **Motor**, the subsystem which moves the system or parts of it in relation to part or all of its environment in relation to each other.	19. **Output transducer**, the subsystem which puts out markers bearing information from the system, changing markers within the system into other matter-energy forms which can be transmitted over channels in the system's environment.
10. **Supporter**, the subsystem which maintains the proper spatial relationships among components of the system, sot that they can interact without weighting each other down or crowding each other.	

Note. From Living Systems, by J. G. Miller, p. 3. Copyright 1978 by McGraw-Hill, Inc. Adapted by permission.

function (see Table 1) is accomplished by a wide range of individuals, such as teamsters and postal workers, using a variety of tools like sorting machines, trucks, and airplanes.

3) Since all systems share theses 19 subsystem processes, it is possible to identify **cross-level generalizations** that assist in the study of living systems. For example, Miller (1978) surveys data on information input overload that demonstrates that the same basic relationship is found at all system levels. Specifically, the data demonstrate that as input to a system increases, its output initially increases, then decreases. Many other cross-level generalizations may be examined to assist our understanding of system processes. Table 2 shows examples of these subsystem processes at the level of the organism and the group. Many additional details may be found in Miller (1978).

Temporary Subsystem Processes

Subsystems can aggregate temporarily to accomplish a function, then break up when that particular function has been completed. This may occur numerous times during instructional system development. In addition, individuals and groups may simultaneously engage in multiple subsystem processes. It is important that individuals engaged in ADL system development understand who participates in each subsystem process so information can be efficiently transmitted when and where it is needed. The next section discusses instructional systems and how the application of system concepts can be applied to ADL systems. Several system approaches will be then be used to illustrate analyses of selected ADL system and subsystem functions.

Table 2

Examples of the 19 Critical Subsystems in an Organism and a Group

Subsystems Which Process Both Matter-Energy and Information		
	Organism	**Group**
Reproducer	Eggs, sperm, sex glands	Persons that produce implicit or explicit charter for group.
Boundary	Epidermis, fur, hair, artifacts (hat, coat, astronauts suit)	Membership committee, sergeant-at-arms, artifacts (room, building, wall)

Subsystems Which Process Matter-Energy			Subsystems Which Process Information		
	Organism	**Group**		**Organism**	**Group**
Ingestor	Mouth, jaws, artifacts (stomach tube, syringe)	Refreshment committee, budget manager who accepts fund transfers	**Input Transducer**	Components of all sensory modalities (e.g., eyes, ears, chemoreceptors), artifacts (radio receiver)	Lookout, scout, artifacts (e-mail)
			Internal Transducer	Postsynaptic regions of neurons	Subgroup or person who receives information about group tasks and conveys it to decider
Distributor	Blood & lymph vascular systems	Person who passes out tools to work group, artifacts (delivery truck)	**Channel and Net**	Network of neurons, hormones (conveyed by blood and lymph systems)	Each group member who communicates to other members, artifacts (written messages)
Converter	Mouth, teeth, digestive system	Chopper of wood, butcher, artifacts (hand tools)	**Decoder**	Retinal bipolar and ganglion cells, cochlear bipolar cells	Guide, interpreter, radar man
Producer	None known	Cook, tailor, maintenance technician	**Associator**	Specific components not known	Laterally dispersed to members who associates bits of information, artifacts (databases)
Matter-Energy Storage	Fatty tissues, liver, bone marrow	Stock clerk, spare-parts man	**Memory**	Brain processes (specific components not known)	Secretaries, treasurers, artifacts (notes, computer files)
			Decider	Parts of cerebral cortex, artifacts (calculator)	Chairperson, selected specialists
			Encoder	Temporoparietal area of dominant hemisphere of brain	Persons composing letter, briefing, or statement presenting views of group
Extruder	Kidneys, rectum, breathing passages, sweat glands	Janitor, "bouncer"			
Motor	Muscles, bones and joints, legs, artifacts (cane, cart, automobile)	Artifacts (bus, truck, plane), may be laterally dispersed to persons who plan and execute group movement	**Output Transducer**	Exocrine glands, inferior frontal cortex of dominant hemisphere of human brain, artifacts (pencil, radio transmitter, computer network)	Subgroups or individuals who deliver reports or statements for the group (spokesman, publicity agent, chairman)
Supporter	Skeleton, tendons, muscles, artifacts (chair, platform)	Person(s) supporting others in group, artifacts (e.g., room car, furniture)			

INSTRUCTIONAL SYSTEMS AND ADL AS AN INSTRUCTIONAL SYSTEM

Often individuals distinguish between training and education, the former focusing on job skills and the latter on general knowledge. For the purposes of this report, both of these categories will be included under the term instructional systems.

ISD AND SYSTEMS APPROACHES TO TRAINING

The objective of instructional systems is to change behaviors so individuals can perform their jobs more effectively. Recognizing the systemic nature of instruction, the military mandated use of the Instructional Systems Development (ISD) process (Branson, Rayner, Cox, Furman, King, & Hannum, 1975). ISD is a result of conceptual development that can be traced to the emergence of systems analysis during World War II (Montemerlo & Tennyson, 1976).

Systems analysis was developed to solve problems associated with weapon systems that were so complex that their understanding "strains human comprehension when initially viewed in their entirety" (Montemerlo & Tennyson, 1976, p. 9). Several efforts during the 1950's and early 1960's attempted to apply systems analysis to training development (Miller, 1954; Kershaw & McKean, 1959; Hoehn, 1960). These and similar efforts were labeled systems approaches to training (SAT) and served as the prototypes for the subsequent development of ISD (Branson & Grow, 1987). Unfortunately, SAT was unsuccessful because too many individuals assumed that the labor-intensive methods and models used by training development experts could be applied by laymen, if they were given simplified procedural checklists. Over 100 proceduralized SAT manuals were produced between 1960 and 1975 (Montemerlo & Tennyson, 1976). These manuals adopted the label SAT, but abandoned the interdisciplinary approach and methods of SAT. Furthermore, many educational psychologists (e.g., Campbell, 1971; Glaser & Resnick, 1972; McKeachie, 1974) concluded that the available theory and empirical evidence on learning processes did not support this over-simplified approach. Nevertheless, many training managers expected the proceduralized approach to work. When it did not, they concluded that the systems approach was not an effective method for the design of instructional programs (Montemerlo & Tennyson, 1976). This negative view of the systems approach has made it very difficult to implement ISD. A greater appreciation of the systemic nature of ISD will support the use of more flexible methodologies for ADL development.

INSTRUCTIONAL SYSTEM PROCESSES

An **instructional system** consists of the planned interaction of people, materials, and techniques, with the goal of improved human performance as measured by established criteria on the job. Table 3 lists some of the types of people, materials, and techniques involved in instructional system development. Each element listed in Table 3 can be viewed as part of one or more group subsystem processes. Each process is influenced by its own perspectives, interests, and goals, based on its relationship to the whole instructional system. Furthermore, like any other system, these subsystems affect and are effected by each other to various degrees.

Table 3

Some of the Major Elements of an Instructional System

People	Materials	Techniques
• Students • Instructors • Content Developers • Instructional Administrators • Subject Matter Experts • Training Aids, Equipment, & Simulator Developers • On-the-job Supervisors • Instructional System Researchers	• Training Aids, Equipment, & Simulators • Instructional Requirements Documents • Instructional Evaluation Instruments • Instructional Development Tools (e.g., authoring systems)	• Instructional Requirements Analysis Methods • Instructional Design Approaches • Instructional Strategies • Instructional Development Methods • Training Aids, Equipment, & Simulator Design Methods • Training Effectiveness Analysis Methods • Cost Effectiveness Analysis Methods • Logistics Analysis Methods

ISD can be depicted as a cyclical or iterative process. Various ISD models divide this process into different numbers of phases (e.g., the main DoD model includes five phases, Branson, et al., 1975; a model endorsed by the American Society for Training Development has four phases, Rothwell & Kazanis, 1998) . Figure 3 is a diagram of this cycle divided into four phases. Each section of the cycle influences every other section either directly or indirectly, through the interactions of people, materials, and techniques (as listed in Table 3). It is also important to note that external factors (e.g., technological developments, policy constraints, and changes in job requirements) also are powerful influences in this cycle.

The instructional development cycle may be further divided into subsystem activities supporting each ISD phase (see Figure 4). As mentioned above, many of these subsystem activities are time-dependant processes, which end when their immediate goal is achieved and their product is passed on to another subsystem activity. For example, the selection of an instructional strategy is usually completed early in the developmental phase based on inputs from other activities, such as the development of instruction by objectives. If the instructional objective is mastery of a motor skill, the instructional strategy will probably include guided practice and feedback. Throughout the ISD process, these subsystem activities are supported and influenced by previous activities and also support and influence subsequent activities. Figure 4 is oversimplified; it does not depict multiple instances of activities in different or multiple developmental phases. For example, formative evaluations may be conducted during the program development phase as well as during program implementation.

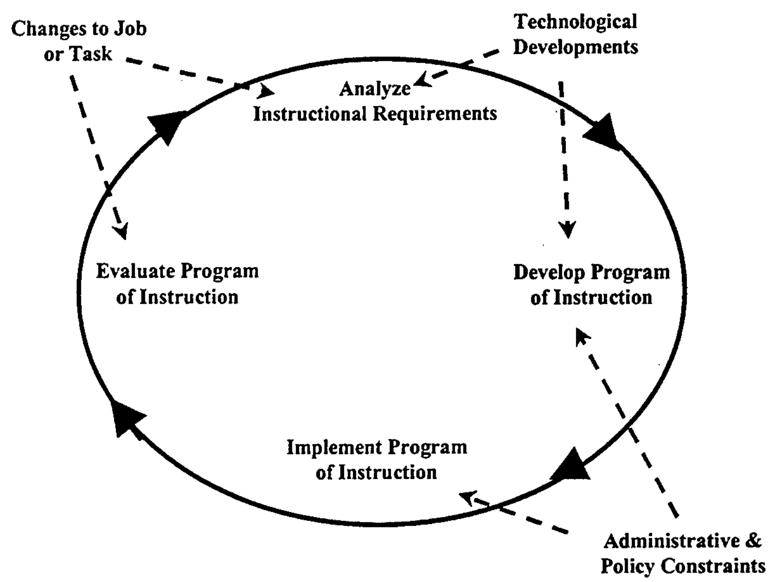

Figure 3. Phases of the Instructional Development Cycle

ADVANCED DISTRIBUTED LEARNING (ADL)

Many educators, program managers, and instructional developers believe that ADL will be a major training tool in the 21st century. The Department of Defense (DoD) provides the following definitions in its ADL Implementation Plan (DoD, 2000):

> ***Learning*** is defined as the acquisition of knowledge, skills, behaviors, and attitudes (through the integration of education, training, and performance support in a comprehensive, mutually supportive system).
> ***Distributed Learning*** (*encompassing programs also referred to as distance learning*) is defined as structured learning that takes place without requiring the physical presence of an instructor. Distributed learning is synchronous and/or asynchronous learning mediated with technology and may use one or more of the following media: audio/videotapes, CD-ROMs, audio/videoteletraining, correspondence courses, interactive television, and video conferencing.
> ***Advanced Distributed Learning*** is an evolution of distributed learning (distance learning) that emphasizes collaboration on standards-based versions of reusable objects, networks, and learning management systems, yet may include some legacy methods and media. (p. ES-2; emphasis in original)

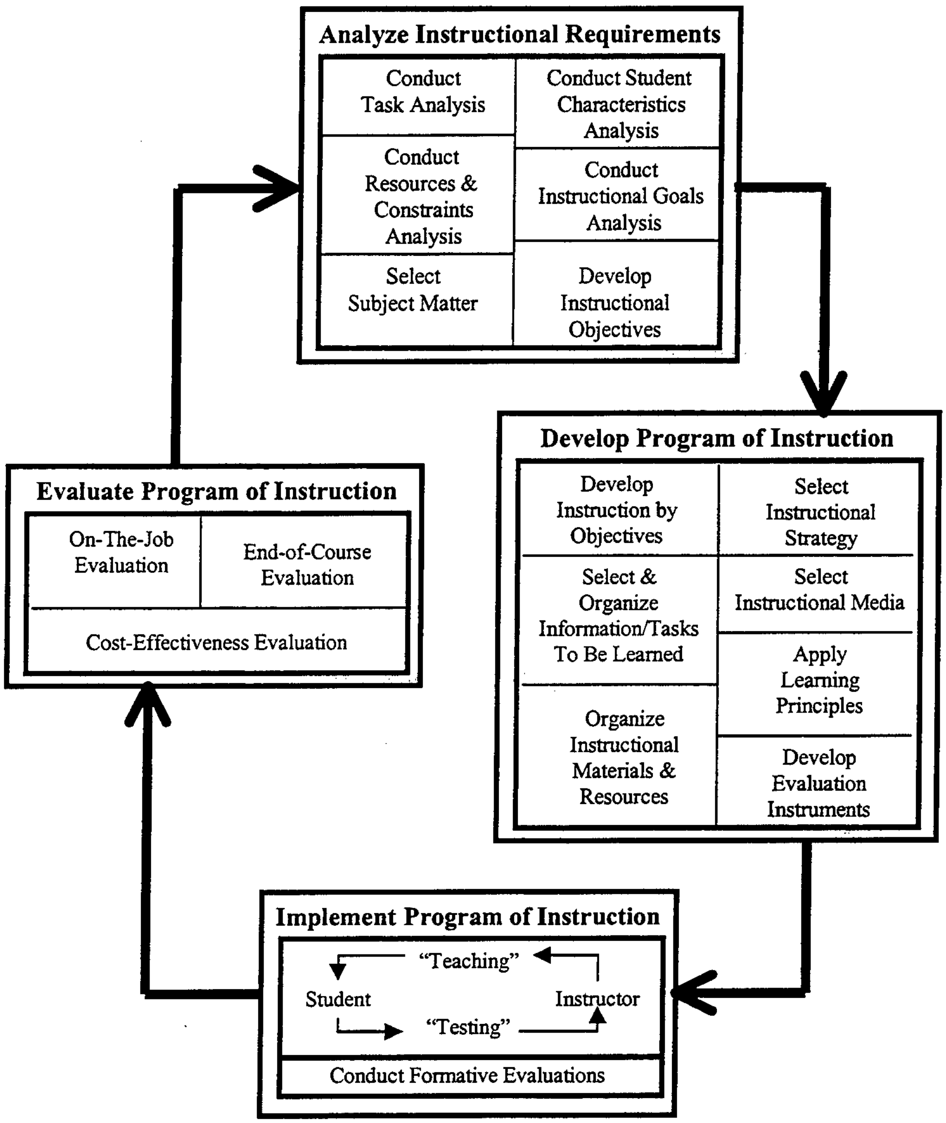

Figure 4. Selected Instructional Development Subsystem Processes

Although a different medium of instruction, ADL systems operate under the same system constraints as any other type of instructional system. Therefore the ISD and system concepts discussed above can be beneficially applied to ADL systems.

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SYSTEM APPROACHES APPLIED TO ADL

System theories provide a variety of tools to analyze and improve ADL processes. Equally important as these tools, a system perspective changes the way one views the world. "A large part of the battle is getting the concept accepted...so that they appreciate the interactions of members of a system and the environment, and to be on the watch for such interactions" (Rubin, 1971, p. 11).

CONSIDERATIONS TO HELP UNDERSTAND ADL SYSTEMS

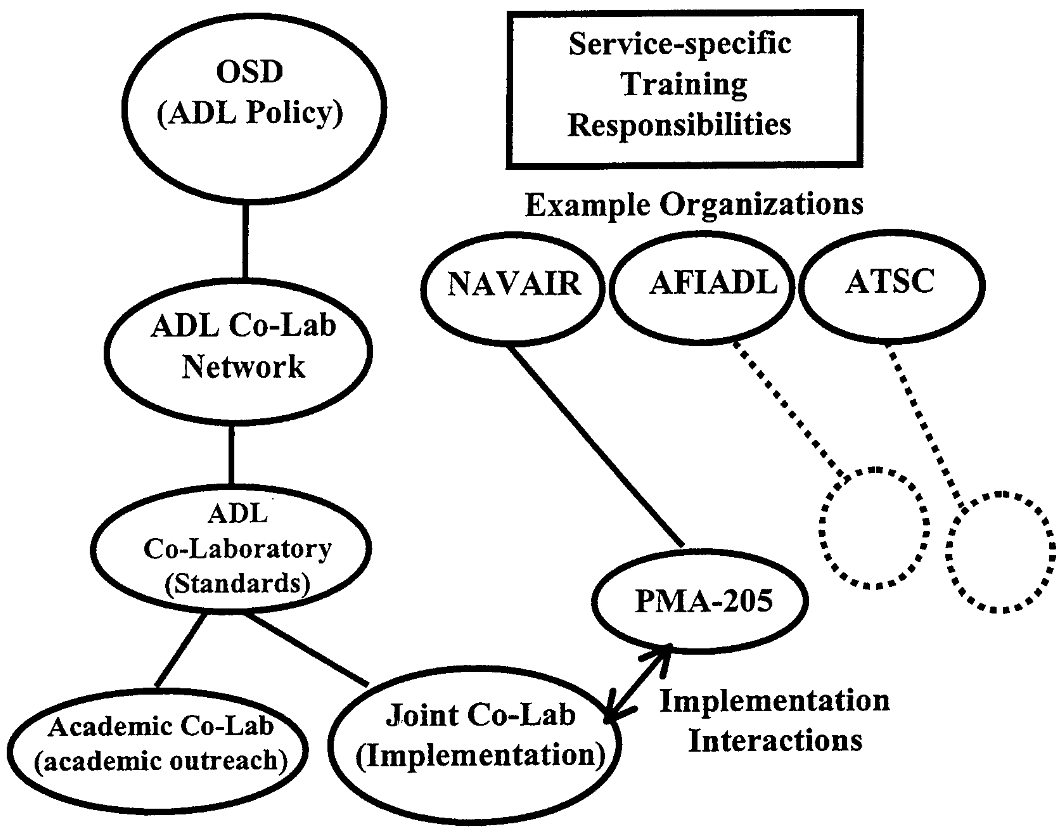
Churchman (1968) identified five basic considerations, which help individuals understand important aspects of systems. These considerations will serve as the orientation for the following discussion of ADL systems. Selected system approaches will be applied to illustrate how they can help reorganize complex ADL processes into forms that are easier to understand (Weinberg, 1975).

Total ADL System Objectives

Churchman's (1968) first consideration is to be aware of the **total system objectives** and more specifically, the performance measures of the whole system. It is often difficult to determine the objectives of the total system because most individuals do not realize that their subsystem is not autonomous. Once this realization occurs, the focus of analysis can be expanded to the network of sub- and suprasystems that affect the local subsystem.

To analyze the total ADL system goals, one must first examine the sub- and suprasystem relationships. Figure 5 is a very simplified diagram showing some of the relationships between several DoD organizations involved in ADL. The Office of the Secretary of Defense (OSD) is shown on the top left of Figure 5. OSD has the responsibility for executing the ADL Initiative to help actualize the vision summarized by the Secretary of Defense. "The Department of Defense's vision is to ensure that Department of Defense personnel have access to the highest quality education and training that can be tailored to their needs and delivered cost effectively, anytime and anywhere" (Cohen, 1999, quoted in DoD, 2000, cover materials). This primary objective governs the efforts of the organizations shown in Figure 5 to varying degrees. As the following discussion demonstrates, each of these organizations has its own responsibilities, which may lead to conflicts in realizing the primary objective.

OSD has established the ADL Co-Laboratory network (shown on the left side of Figure 5). This network, as reflected by its title, fosters collaborative efforts to advance the ADL Initiative. It consists of the ADL Co-Laboratory whose "most critical function is to develop, evaluate, and promote ADL standards" (DoD, 2000, p. ES-3). Two Co-Lab nodes, the Academic Co-Lab and the Joint Co-Lab, have additional objectives. The Academic ADL Co-Lab promotes the development of ADL technologies, principally among academic institutions. The Joint ADL Co-Lab "was established to promote collaborative and rapid development of ADL prototypes and ADL system acquisitions" (DoD, 2000, p. ES-3). This goal brings the Joint ADL Co-Laboratory into a direct relationship with some of the organizations charged with implementation of ADL.



Note. OSD=Office of the Secretary of Defense;
NAVAIR=Naval Air Systems Command;
AFIADL=Air Force Institute for ADL;
ATSC= Army Training Support Center;
PMA=Program Manager Aviation

Figure 5. Example Relationships Among Some ADL Organizations

A small example of the many organizations, which implement ADL is shown on the right side of Figure 5. This simplified view depicts three service specific organizations: the Naval Air Systems Command (NAVAIR), the Air Force Institute for ADL, and the Army Training Support Center (ATSC). Each of these organizations has different degrees of responsibility for the ADL training being implemented in the Navy, Air Force, and Army. Due to space limitations, this discussion will focus on NAVAIR, but it should be noted that similar activities and organizations are found in the other services.

NAVAIR is the Navy's principal command for the development, acquisition, and support of naval aeronautical and related technology systems. The acquisition of aeronautical training systems is accomplished by PMA-205. ADL systems are part of this responsibility. As such, PMA-205 is in the process of converting thousands of legacy courses for delivery on the internet, as well as developing new ADL courses. It must accomplish this on a tight schedule and may seek implementation advice from the Joint ADL Co-Lab.

Here is an example of where a goal conflict may arise. The Joint ADL Co-Lab, as part of the ADL Co-Lab network, fully supports the development of ADL standards, embodied in the Sharable Content Object Reference Model (SCORM). SCORM is being developed as a multiyear effort, with the participation of various industry associations and professional organizations. SCORM development is proceeding through various versions, each more comprehensive than the last. Version 1.0 was released in January, 2000 and version 1.1 was released in January, 2001. Version 2.0 is scheduled to be released during 2001 and subsequent versions may follow.

The Joint ADL Co-Lab is also tasked with assisting in the implementation of ADL in the military training acquisition community. PMA-205 seeks immediate assistance to help them conform to SCORM while meeting their course conversion and development schedule. Unfortunately, SCORM is an evolving standard and does not currently support important instructional requirements. For example, SCORM does not include a mechanism for passing the results of performance testing from one, stand-alone learning object to another. To be conformant with the current SCORM, instructional developers either need to wait for more comprehensive versions or recommend suboptimal instructional strategies. The latter is not an acceptable solution, so the Joint Co-Lab is forced to recommend compromises on SCORM to meet PMA-205's short-term schedule. A plan for content development in the "spirit of SCORM" (e.g., organizing content into small stand-alone learning objects and later tagging these content objects with conformant SCORM meta-data) may enable DoD organizations to meet both sets of goals. Many other examples of goal conflicts can be identified and resolved through a total-system goal analysis.

Understanding the ADL System's Environment

The second of Churchman's considerations is to understand the system's environment—the **fixed constraints** that affect the system. One of the fixed constraints on an ADL system is the channels that bring information into and out of the system. In LST terminology, the subsystem that brings information into a system is called the input transducer (Miller, 1978). This function may be upwardly dispersed to the suprasystem (e.g., tasking memoranda or press releases), laterally dispersed to multiple individuals in the system (e.g., attendees at policy meetings), downwardly dispersed to one or more subsystems (e.g., individuals obtaining data to support a specific subprocess), or various combinations. This dispersion of the input transducer function may result in conflicting or delayed information required by other subsystem processes.

Another important aspect of the analysis of an ADL system's informational constraints, is to search for sources of information distortion. Such distortion can be due to a variety of conditions including information overload. However, in organizations, the distortion of information is often due to biases introduced by components evaluating information from a local rather than a system-wide perspective. Individuals may report what they believe their superiors want to hear or what they want them to hear (Guetzkow, 1965; Katz & Kahn, 1966). Identification and removal of sources of information distortion will enhance organizations' abilities to advance the ADL agenda.

Environmental constraints also include the external forces that influence ADL system development. Some of these forces are shown in Figure 3; they include:

• Technological developments, which influence how instructional content may be delivered to students. For example, delivering web-based instruction to students aboard ship is constrained by available bandwidth. As new technologies expand bandwidth, additional instructional options (e.g., streaming video) become available.

• Administrative and policy constraints influence how ADL content will be developed and delivered. For example, delivery of instruction over the web has security implications that must be understood by instructional developers and may influence the instructional strategy chosen.

• Job changes must be constantly monitored to ensure that ADL instruction is current, providing the latest, most accurate information.

Understanding the Resources Available

Churchman's (1968) third consideration is to understand the **resources available** to the ADL system. Instructional developers are often asked to do more with less. However, it is important that a comprehensive analysis of the resource requirements be conducted to determine whether the goals of an ADL program can be achieved. If sufficient resources are not available, or if resources are spread across too many efforts, alternate plans should be formulated.

Understanding ADL Subsystem Components

One should be aware of the **components (subsystems)** of the ADL system in terms of their activities, goals, and measures of performance. Organizing the analysis using Miller's (1978) critical subsystem processes can provide a useful starting point. Each subsystem process (see Tables 1 and 2) should be examined as it relates to all other processes. For example, the associator is the subsystem that carries out the first stage in the learning process of the system. To form enduring associations, the associator must receive information from the input transducer and the internal transducer via the channel and net. It must then transfer this information into memory for longer-term storage. An ADL subsystem analysis needs to identify the individuals, groups, and organizations that carry out these and other subsystem processes. Next, the specific information channels and decision points can be identified and evaluated. Finally, the impediments to successfully reaching subsystem goals in each information channel can be removed or reduced.

Understanding the Management of the ADL System

The fifth consideration for understanding ADL systems is to identify and understand the **management of the system**. This includes the constraints imposed upon it by its suprasystem or multiple suprasystems (see Figures 1 and 2). In ADL systems, these constraints include some of those discussed above (e.g., goal conflicts, lack of resources, and information distortion). A more subtle constraint, related to information distortion, is the suprasystem perception that goals have been achieved. Because the suprasystem's information is more general and may be distorted by subsystem inputs, it is easy to overestimate the success or degree of completion of subsystem efforts. This could be the result of imprecise or improper measures of performance. It could also be the result of the suprasystem overselling results to its controlling suprasystem. It is equally important for the suprasystem components to understand system relationships and the constraints it imposes upon its subsystems as it is for the subsystem components to recognize the constraints imposed by their suprasystems.

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ADL SYSTEM RESEARCH AGENDA

A system perspective can help ADL researchers identify areas, which will generate benefits for the total ADL system. At a minimum, the following topics require additional research.

APPLY SYSTEM CONCEPTS AND APPROACHES TO ADL

The above discussions have provided simple examples of some system concepts (e.g., the 19 critical subsystems) and approaches (e.g., information flow analysis). Researchers need to conduct more in-depth application of these concepts and tools in the specific ADL system context. Each ADL effort should be analyzed in terms of the critical subsystem processes. Which individuals or groups are involved in each process or multiple processes? Are they aware of their involvement in a given process? What are their resources and constraints? How do they communicate to other processes? The answers to these and many other questions are required before meaningful actions may be taken to improve the quality of the ADL efforts.

In conducting a system analysis of ADL efforts, special emphasis should be placed on the interfaces between various subsystems and subsystem processes. Information and other products from each subsystem process pass to other systems or subsystem processes across these interfaces. It is at the interfaces that problems often occur (e.g., information overload or information distortion). The structures and functions that help or hinder transfer across subsystem interfaces can be analyzed and improved.

CROSS-LEVEL GENERALIZATIONS

A large body of empirical data demonstrates that many cross-level generalizations can guide our analysis of systems (Miller, 1978). Researchers can identify and apply these to support ADL analyses. For example, at the cell level, the boundary function includes the semi-permeable cell membrane. This semi-permeability allows certain substances to pass into the cell while blocking others. It is likely that an analogous process occurs in ADL systems. Certain types of information are recognized and acted on by the ADL system and other types are blocked or ignored. A detailed analysis of the ADL system boundary will help identify problems and improve information flow. Many other cross-level generalizations can be identified and used to focus ADL system analysis efforts.

IDENTIFICATION OF ADL SYSTEM RELATIONSHIPS

It is vital to understand the scope of ADL efforts. Many organizations are conducting collaborative ADL efforts (e.g., the ADL Co-Lab Network). However, many other organizations have their own ADL agendas, sponsors, and constraints. A comprehensive survey of ADL activities will help identify projects, which duplicate or compete with one another. It can also identify where areas of collaboration exist and can be expanded.

ADL GOALS AND NEEDS ANALYSIS

Once ADL organizations and their relationships have been identified, the focus can be shifted to an analysis of each organization's goals and needs. A systems perspective helps to illuminate possible goal conflicts between various subsystem activities. Identification and reduction of these conflicts will enhance collaboration in the total ADL development process. Comprehensive ADL needs analysis requires tools and methods to identify the goals and communication mechanisms of each ADL sub- and suprasystem. Special emphasis should be given to how the suprasystem communicates its goals to its subsystems and how these goals are interpreted at the subsystem level. It is also important to identify how the goals and needs of individuals working on one subsystem process are communicated to individuals engaged in other subefforts. The identification and communication of goals and needs across subsystems will help avoid duplication of effort and enhance the use of one subsystem's products by individuals working in other areas.

ADL DEVELOPMENT GUIDELINES

Since ADL is a new instructional approach, ADL developers need the best possible guidance to help them achieve their goals. Some guidance can be found in the Human-Computer Interface (HCI) literature or the literature on computer-based instruction (e.g., choice of font size or use of colors on computer screens). Other guidance is specific to ADL instruction (e.g., when to use e-mail or chat rooms as part of an ADL course). The results of an ongoing effort to accumulate ADL design and evaluation guidelines (Hamel, Ryan-Jones, & Hays, 2000) will be of greater utility if they are organized from a total ADL system perspective. Guidelines may become too narrowly focused on a limited number of subprocesses at the expense of others. Researchers who are developing or accumulating and validating ADL guidelines must be aware that providing guidance to individuals working on one subprocess will not guarantee effective ADL systems if individuals engaged in other subprocesses lack guidance.

The ISD process (e.g., Figure 3) can provide the initial organization for the guidelines. Each guideline should address HCI (appearance and usability) and informational (instructional content) issues. This is similar to the analysis of physical and functional fidelity requirements used by many simulator developers to guide their efforts (Hays & Singer, 1989). Like physical and functional fidelity, the HCI and informational components are analogous to the visual components of brightness and hue. Neither can be changed without some degree of change in the other. Both aspects must be addressed to ensure that ADL decisions do not result in counterproductive effects.

It is also necessary to target ADL guidelines toward the various disciplines that undertake various ISD subprocesses. For example, some guidelines should be targeted toward the instructional developers and others toward the web programmers. Without focusing the ADL guidelines on the requirements of individuals from various disciplines, they may not be useful to the people who need them during each ISD phase.

ADL guidelines should be based on empirical research, especially those that address instructional strategies. Although data on the effectiveness of instruction has been collected in classrooms (e.g., Bloom, 1984) and in the context of training simulation (e.g., Hays & Vincenzi, 2000), there is a dearth of data on the effectiveness of ADL applications. As ADL guidelines are accumulated and applied, gaps in the empirical foundation for the guidelines can be identified and used to identify and justify ADL research agendas. Data from this research may then be used to make informed decisions on the selection of ADL instructional strategies.

EVALUATION OF ADL SYSTEMS

Instructional system evaluation is always difficult. Transfer of Training (TOT) has been advocated as the most valid method for measuring instructional effectiveness (Orlansky, 1981) and several TOT models and evaluation designs have been developed (Caro, 1977; Pfeiffer & Browning, 1984; Hays & Singer, 1989). However, TOT is seldom used because of numerous factors (e.g., lack of resources to track students after training and measure their performance at the job site). Cost and scheduling factors may also be used to evaluate instructional systems (Orlansky & String, 1981). Often the type of evaluation is mandated by whichever sub- or suprasystem generates the requirements or provides funds for the evaluation.

Determining the effectiveness of ADL systems is more difficult than some other instructional systems because students can access different types of instruction or job aiding information from diverse locations and it would be prohibitively costly to collect performance data at each location. Tools and methods are needed to ensure that evaluation techniques address the divergent requirements of various ADL organizations and activities. Some evaluations may need to focus on the cost of ADL development and implementation; others on the number of students that have access to instruction or the number of instructors or facilitators necessary to support ADL systems. In most cases, improvements in job performance should be a primary goal of ADL evaluations. Since no evaluation can meet all goals, identification and prioritization of sub- and suprasystem goals can help allocate evaluation resources for the greatest total ADL system benefit.

CONFIGURATION MANAGEMENT OF ADL SYSTEMS

Managers of instructional systems that use simulators have long been aware of the critical need for configuration management. This includes the need to upgrade simulator software as new versions are released. ADL systems present a new set of configuration management issues. For example, if web-based instruction uses links to other web sites, someone needs to monitor each link to ensure that it is operational. Furthermore, it is necessary to ensure that the information on the web sites that are linked to an ADL application is current and continues to support its instructional needs. System techniques and methods can help identify the critical ADL areas requiring configuration management.

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SUMMARY AND RECOMMENDATIONS

Effective ADL systems can become a potent tool to provide the necessary knowledge and skills for individuals to compete in an increasingly complex world. This report has presented a theoretical foundation using a system perspective to aid in the development of a research agenda for ADL systems. System theory focuses on the complex interactions within systems and instills a paradigm shift in the way individuals engaged in the development of ADL systems approach their task. After a brief review of system theories, concepts and approaches, selected system concepts were discussed in the context of the development and evaluation of ADL systems. Guided by the system perspective, the application of system tools and concepts can improve our ability to develop effective and economical ADL systems. Several ADL research areas and issues were discussed and recommendations for system-oriented research were provided.

It is recommended that all individuals engaged in the development of ADL policy and products **adopt a total system perspective**. This perspective will ensure that individuals focus their energy and attention on several important areas:

- Total system and subsystem relationships, to help develop an understanding of all of the various systems that engage in ADL efforts and how they can support one another.

- System and subsystem goals and needs, to facilitate the development of shared goals, rather than wasting efforts on conflicting goals.

- Communication processes between systems and subsystems, to help establish clear lines of communication, reduce information distortion, and enable individuals to engage in collaborative efforts.

- Apply system-oriented tools and methods, to generate data that will support the total ADL system. These data, applied across the entire ADL system, will result in synergy and the rapid advancement of the instructional capabilities that are potentially available from ADL.

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