DOCUMENT RESUME

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|---|---|---|
| ED 482 923 | | UD 035 981 |


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| AUTHOR | Fletcher, J. D.; Tobias, Sigmund |
| TITLE | Implications of the Advanced Distributed Learning Initiative for Education. Urban Diversity Series. |
| INSTITUTION | ERIC Clearinghouse on Urban Education, New York, NY. |
| SPONS AGENCY | Institute of Education Sciences (ED), Washington, DC. |
| REPORT NO | UDS-118 |
| PUB DATE | 2003-12-00 |
| NOTE | 53p. |
| CONTRACT | ED-99-CO-0035 |
| AVAILABLE FROM | ERIC Clearinghouse on Urban Education, Institute for Urban and Minority Education, Box 40, Teachers College, Columbia University, New York, NY 10027. Tel: 800-601-4868 (Toll Free); Tel: 212-678-3433; Fax: 212-678-4012; e-mail: eric-cue@columbia.edu. For full text: http://eric-web.tc.columbia.edu/pubget.asp?show=1. |
| PUB TYPE | ERIC Publications (071) -- Reports - Descriptive (141) |
| EDRS PRICE | EDRS Price MF01/PC03 Plus Postage. |
| DESCRIPTORS | *Computer Assisted Instruction; *Computer Uses in Education; *Distance Education; Distributive Education; Educational Change; Educational Development; Educational Technology; Futures (of Society); Individualized Instruction; *Intelligent Tutoring Systems; Learner Controlled Instruction; Nonprint Media; Technological Advancement; Training |
| IDENTIFIERS | Department of Defense; Interoperability |



ABSTRACT

This monograph in the Urban Diversity Series describes the The Advanced Distributed Learning (ADL)initiative, relates it to research dealing with instruction generally and computer-mediated instruction specifically, and discusses its implications for education. ADL was undertaken to make instructional material universally accessible primarily, but not solely, through delivery on the World Wide Web. The ADL initiative was begun by the U.S. Department of Defense (DoD) in cooperation with the White House Office of Science and Technology (OSTP). It is intended to make education, training, and performance aiding available anytime, anywhere, and to anyone through the use of asynchronous, computer-mediated instruction. The purpose of this paper is to describe the ADL initiative to educators and educational researchers and to invite their participation in shaping and guiding its development and implementation to ensure its contribution to education practice and processes. ADL is of obvious importance to professionals concerned with training and education, but it has promise for other audiences as well. Included among these are individuals in schools serving rural areas remote from libraries and museums, minority students in urban areas attending schools with limited resources, and students seeking elective course offerings in specialized subject areas. Includes a glossary of information technology terms. (Contains 81 references.) (SM)

ED 482 923

# Implications of the Advanced Distributed Learning Initiative for Education

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ERIC Clearinghouse on Urban Education
Urban Diversity Series No. 118

December 2003

ERIC
Educational Resources Information Center



UD 035 981

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This publication was produced by the ERIC Clearinghouse on Urban Education, with funding from the Institute of Education Sciences (IES), United States Department of Education, under contract number ED-99-CO-0035. Additional support was provided by Teachers College, Columbia University. The opinions expressed in this publication do not necessarily reflect the position or policies of IES, the Department of Education, or Teachers College.

## Implications of the Advanced Distributed Learning Initiative for Education

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Abstract

The Advanced Distributed Learning (ADL) initiative is intended to enhance the efficiency of training and education programs by making instruction, scheduling, performance aiding, and performance support materials available anytime and anywhere to anyone who needs them. It emphasizes the use of asynchronous, computer-mediated instruction to achieve its objectives. This paper describes the ADL initiative, relates it to research dealing with instruction generally and computer-mediated instruction specifically, and discusses its implications for education.

**Implications of the Advanced Distributed Learning Initiative for Education**

The Advanced Distributed Learning (ADL) initiative was undertaken to make instructional material universally accessible primarily, but not solely, through delivery on the World Wide Web. The initiative was undertaken by the U.S. Department of Defense (DoD) in cooperation with the White House Office of Science and Technology (OSTP). It is intended to make education, training, and performance aiding available anytime, anywhere, and to anyone through the use of asynchronous, computer-mediated instruction. The purpose of this paper is to describe the ADL initiative to educators and educational researchers and to invite their participation in shaping and guiding its development and implementation to ensure its contribution to education practice and processes.

ADL is of obvious importance to professionals concerned with training and education, but it has promise for other audiences as well. Included among these are individuals in schools serving a rural area remote from urban amenities such as libraries and museums, minority students in urban areas attending schools with limited resources, and students seeking elective course offerings in specialized subject areas. ADL is also important for people such as caregivers, shift workers on erratic schedules, severely disabled individuals, and others who do not have time or resources to attend schools in order to continue their education. It is of equal interest to individuals and organizations concerned with life-long learning, people needing continuing education and training in rapidly changing or evolving fields, and those caught in unsatisfying jobs who want to continue their preparation for alternate careers without taking time off for travel to a campus.

Even though little about ADL has appeared in the educational literature, issues relevant to it have been addressed by a number of scholars. For example, Seidel and Cox (2003) emphasized the substantial planning required to develop and adopt educational innovations in general and technology-based education in particular. A volume devoted to descriptions of projects using computer technology for instruction (O'Neil & Perez, 2003) includes a number of recent efforts pertinent to ADL. Gibbons, Nelson, and Richards (2000) discuss the nature and value of instructional objects, i.e., self-contained instructional modules, for education. Graesser, Wiemer-Hastings, Wiemer-Hastings, Kreuz, and the Tutoring Research Group (2000) have demonstrated that students can interact with computers using mixed initiative educational dialogue, i.e., interactions that use a restricted vocabulary related to the content of instruction and allow either the computer or the student to initiate dialogue interactions. Such interactions are similar to those intended for use in ADL. These contributors, among others, provide the background for a description of ADL and a discussion of its importance for education.

## ADL, Education, and Training

As suggested by agreements between OSTP and DoD, ADL is intended to develop and provide its capabilities first to DoD, then to all federal agencies, and finally to anyone seeking ready access to education, training, or performance aiding. ADL instructional material consists of objects that are to be accessible to all learning systems (e.g., authoring systems, learning management systems monitoring student's work, and content management systems tracking and sequencing the learning materials); interoperable across all platforms and especially the browsers that are available across the World Wide Web; and durable across evolving versions of underlying software tools and services such as authoring systems and operating systems. Finally the instructional objects will be reusable so that anyone developing new education and training materials can employ those learning objects in their own courseware, in addition to the courses for which they were originally developed. We expect ADL instructional objects to become as widely used in educational contexts as they will be in training and performance aiding.

The ADL Vision

ADL's stated vision is to "ensure access to high-quality education, training, and decision aiding ('mentoring') materials that can be tailored to individual learner's needs and made available anywhere, anytime" (SCORM, 2001, p. 1-11). Visions of this sort are used to guide and prioritize research and to describe as succinctly as possible a desired future condition. Over the last 40 years or so, many individuals who saw in computer and communications technology the promise for actually achieving the capabilities suggested by the ADL vision have contributed to its realization. Much progress has been made, but more is needed before it becomes reality.

ADL may affect not only the instructional procedures and practices of the Federal agencies and those of industry, but also and inevitably those of K-12 schooling and post secondary education. The ADL vision is straight-forward, but its insistence on accessibility - on individualized instruction that is available to all learners anytime and anywhere - leads to implications that deserve the attention of everyone who is concerned with the progress of educational approaches, practices, and the development of human potential.

Much of the current ADL focus is on training and life-long learning, but education shares many, perhaps most, of its requirements, functional operations, and capabilities with training (Tobias & Fletcher, 2000). Training usually means instruction that prepares people to perform specific tasks and jobs. It is a means to an end, preparing individuals and groups for the relatively short-term, definite future. It stands in contrast to education, which is usually viewed as an end in its own right, preparing students for the long-term, indefinite future. However, it is as difficult to find training that excludes objectives and materials that contribute to the education of the individuals involved as it is to find education without components -- in many cases substantial components -- of what is in effect, training.

Both education and training may be placed on the same dimension, which for convenience may be called instruction. Training and education appear to be distinguished from each other more by purpose than by process, more in what they emphasize than in their techniques. Both are intended to promote human learning. ADL is likely to be as relevant to education as it is to all other forms of instruction.

ADL and Defense

The ADL strategy, implemented by Presidential Executive Orders and agreements with various Federal agencies, requires the DoD to lead the ADL initiative by developing instructional approaches and providing guidelines for other Federal agencies. This central role for DoD may surprise some educators. However, DoD involvement in all levels of instruction is both sizable and comprehensive. The DoD expends about $17 billion annually to educate and train individuals in formal, residential settings such as the military academies, staff colleges, and schools providing specialized skill training. When the costs of informal, non-residential training and education, such as on-the-job training and exercises conducted in operational units, are included, these expenditures may exceed $50 billion per year. About 85 percent of this training and education involves preparation for tasks, jobs, and occupational skills that are non-combatant, with direct civilian counterparts (Fletcher & Chatelier, 2000). Moreover, and in contrast to the localized nature of public schooling in the United States, DoD instructional activity occurs "under one roof." It is subject to centralized guidance and direction from the Secretary of Defense.

DoD training and education is not limited to people in uniform. In addition to 1.3 million military personnel, about 800,000 civilian employees receive DoD-supplied education and training. The DoD also spends 1.3 billion annually to provide K-12 schooling for about 110,000 military dependents overseas and in the United States. These schools are noted for their ability to establish and maintain high levels of achievement among a diverse and mobile population of students (Smrekar, Gutherie, Owens, & Sims, 2001). Given the scope and intensity of DoD instructional efforts, it is not unreasonable to ask and expect the Defense community to exercise leadership in developing ADL.

ADL and Instruction

ADL is *Advanced* in that it uses technology and a common framework to provide computer based reusable, platform-independent software to generate presentations and instruction tailored to the needs of individual learners and other users. It is *Distributed* in that it is to be delivered, updated, and managed using network technologies -- although it can just as well be used in ordinary classroom instruction. It centers on *Learning* because it encompasses education, training, life-long learning, and performance aiding provided anytime, anywhere (SCORM, 2001).

The ADL vision reflects a progression of educational development that has continued through much of human history. It may effect a third significant revolution in this history. The first revolution occurred with the development of written language, which made the content of learning available anytime, anywhere to anyone who could obtain and read written records. The second revolution occurred with the development of moveable type and books, first by the Chinese in the 11th Century AD and then in Western Europe in the 15th Century (Kilgour, 1998). Not only did books make the learning of sages (among others) accessible anytime and anywhere, they also made it replicable and affordable. They increased the appetite and demand for learning among ever greater numbers of people who, in turn, raised the demand for books.

We may now be on the threshold of a third revolution in this history. With its ability to adapt to the conditions of the moment on a microsecond-to-microsecond basis combined with its ever-increasing ubiquity, computer technology has made not just the content of learning but also the interactions of tutorial instruction inexpensively and globally accessible. It may whet the appetite for learning among still greater numbers of people, who in turn will intensify the demand for it. The promise of computer technology for education has outstripped its actuality for some five decades now. The ADL initiative should narrow this gap.

Predicting the future is always risky. As Samuel Johnson noted, it mainly serves to provide amusement for future generations. On the other hand, a number of projects that have used a futurist perspective to plan for and implement educational change have demonstrated the usefulness of this approach. For instance Tobias (1977, 1980) examined the curriculum in different fields from the perspective of the knowledge, skills, and attitudes students would need at the turn of the twentieth century. Trends in a variety of pertinent areas were examined and projected into the coming new century. This work succeeded in revising the Business Education curriculum in New York State so that knowledge and skills that were obsolete, or about to become obsolete, were removed from the curriculum, and replaced by others that were becoming important with the advent of new technology.

One prediction made more than a quarter century ago is particularly interesting. Henriquez (1977) predicted that within ten years, or by 1987, at least fifteen percent of the educators and business people, to whom the report was directed, would have their own personal computers and do much of their office work on those machines (Tobias, 1977). It must be recalled that this prediction was made just when the Apple II appeared, IBMs' line of personal computers had not yet been introduced, and the DOS operating system was yet to be distributed. That prediction, which turned out to be an underestimate, prompted New York State to change the teaching of a number of items in the Business Education curriculum. One specific example is indicative of these changes: the teaching of typewriting was changed to emphasize general data entry skills that would be applicable to new technological equipment. These changes had a significant impact on the lives and capabilities of students in New York State. We hope and predict that ADL will effect similar changes and have an equally significant impact on students in schools.

<u>ADL and Education</u>

Few educators would deny the appeal of capabilities that make learning more widely available. However, since ADL may change the practices and processes of current institutions of education, many educators may reasonably be concerned about its impact on their organizations. Favorable responses to emerging ADL capabilities have been rapid and intense in the world of post-secondary school training and life-long learning where investments in learning produce measurable profits, enhance productivity, and increase effectiveness. The world of K-16 education may be similarly affected, but in less predictable ways. The capability to provide learning anytime, anywhere will bring about change and require adaptations by existing, classroom-centered institutions.

Responses by educators are needed to harmonize current practices with those that are emerging from ADL to ensure that the results serve the needs of students, teachers, parents, and administrators and enhance the capabilities, processes, and effectiveness of education. However, educators frequently treat training and life-long learning as alien territory with little relevance to education. The history of developments such as computer-based instruction itself, computer-based testing, instructional simulation, intelligent tutoring systems, and Internet applications suggests otherwise. Vigorous and even enthusiastic participation of educational researchers, decision makers, and policy makers were needed to shape these developments for educational applications. It will also be needed to shape the development of ADL and ensure that the resulting capabilities benefit the full spectrum of educational experiences. Such participation is not just welcome but essential.

Some of this participation has begun. In assessing the educational value of component software, or objects, such as that promoted by ADL, Roschelle and Kaput (1995) emphasized its ability to combine many kinds of interactive content in multiple display formats and attain for education the benefits now being realized in business from the use of integrated office software. Roschelle et al. (1999) described software technologies underlying the development of five object-based education projects and reviewed their relative effectiveness. Gibbons, Nelson, and Richards (2000) have discussed the nature and value of instructional objects for educational applications in some detail.

The attention given to this topic by educators may continue and grow. It is a desirable trend and should be encouraged. This encouragement would be enhanced by the appointment, now under consideration, of someone familiar with education, training, and technology to act as a liaison to facilitate communication between ADL and individuals concerned with educational research and practice. Similarly, discussions are underway to establish special interest groups in professional associations concerned with education and training in order to enhance the exchange of ideas between ADL and those communities.

Scope of ADL

With its emphasis on widely accessible learning, ADL is taking advantage of the explosive growth of electronic commerce and the World Wide Web. The dramatic expansion of the Web is indicated by data showing that "the Internet currently encompasses over 7,000,000 hosts, serving more than 40,000 ,000 end-users, and offering access to some 11,000,000 World Wide Web documents" (http://www.ualberta.ca/~nfriesen/536/intgrwth.htm). The development of instructional materials for the Internet shows similar rapid growth. Duffy and Kirkley (in press) provide an idea of the pace of these developments. "Currently, more than 50,000 university courses are taught online, and more than 1,000 universities are developing and offering these online courses. Corporations are also embracing the Web for instructional delivery. From 1996 to 1998, the proportion of companies using the intranet for training increased from 3.5% to 33.2% and nearly all of the Fortune 100 companies offer some form of on-line computer based training" (p. 2).

In addition to universities, corporations, government, and the military, agencies and consortia such as professional societies, technical interest groups, and industry associations are increasingly turning to the Internet to deliver instruction. ADL builds on this global, almost irresistible activity and accelerates its application to the full range of training, education, and life-long learning possibilities.

The needs of business and industry for education and training also extend the scope of ADL. Funk and McBride (2000) noted that, despite an annual investment of an estimated $210 billion in training, companies continue to cite the lack of qualified workers as the biggest obstacle to economic growth. They suggested that one way to supply the need for qualified workers is to invest approximately twice the current resources currently allocated to education and training, increasing them from about two to about four percent of annual payroll costs.

When combined with education and training, the leverage provided by performance aiding may further extend the scope of ADL. For example, Teitlebaum and Orlansky (1996) summarized the impact of the Air Force Integrated Maintenance Information System (IMIS) and found that technicians having only general training but who used IMIS performed as well as technicians with lengthy (and expensive) training in avionics. Implementing the IMIS system, even if it were limited to the three avionics subsystems examined in its initial trails, would yield a net annual savings to the Air Force of $23 million. These are economies that are equally available to business and industry. Individuals concerned with the ensuring human competence and performance when and where they are needed anticipate similar savings from applications of ADL capabilities in an expanding number of areas.

ADL's influence has become global. International business and industry, faced increasingly with the need to offer training on a worldwide basis are adopting ADL specifications in order to make the training, education, and performance aiding capabilities their employees need conveniently and globally accessible. ADL initiatives have been established by countries in Eastern and Western Europe, Asia, and the Pacific Rim with the intention of either shadowing or contributing to ADL developments in the United States.

Personal Learning Associates

ADL developers envision a future that includes electronic Personal Learning Associates (PLAs). These devices may become as prevalent and widely used as the portable radios, CD players, cameras, portable game players, wireless personal data assistants, cellular telephones, and watches that people carry today. For that matter, PLAs may combine all these capabilities into single devices, a trend that is already evident in extensions of cellular telephone functionalities.

PLAs will be small enough to be carried in a pocket or worn as an article of clothing. They will use wireless communication and natural language querying interactions to assemble and present learning and performance aiding on demand and in real-time -- any time, anywhere. As suggested by its vision, ADL's long-range objective is to tailor such attributes as sequence, content, difficulty, style, pace, level of abstraction, etc., to the needs, abilities, and background of the individual (or group of individuals). Capabilities to attain these goals are being incorporated into ADL while research continues to identify the relevant variables needed to accomplish them.

As mentioned, interactions with PLAs will consist of both written and spoken natural language dialogue initiated either by the learning associates or their user(s). Computer based tutoring systems under development from the 1970s (e.g., Sleeman & Brown, 1982) to today (e.g., Graesser et al., 2000) have used mixed initiative dialogue to interact with students in natural language. These systems have demonstrated the dialogue capabilities PLAs will need and have in the future. PLAs will be used by individuals learning alone, in Web-based discussion groups, in classrooms, or at job sites - basically whenever and wherever they are needed.

PLAs will be used as much for performance aiding as for instruction. Individuals either on the job or in educational settings will be able to turn to a PLA for decision and performance aiding in applications ranging from finance and business planning to tank turret repair and avionics maintenance. Similarly, students will be able to use ADL materials to help them solve problems dealing with issues in virtually all areas across the curriculum, whether they are encountered in school, at home, or anywhere else. The key notion is accessibility - anytime, anywhere.

Most of the technology needed to build PLAs exists now. PLAs can be easily worn on a belt pack and eventually on the wrist. Gordon Moore's (famous) Law suggests that further compaction, miniaturization, and cost reductions are likely. His Law, first articulated in 1965, predicted that computer power and memory would double about every year. Other estimates call for a doubling approximately every two years (Brenner, 1997). If we split the difference and call it 18 months, we find that Moore's law has proved to be surprisingly accurate. It suggests the likely, perhaps imminent, appearance of powerful, wearable, and affordable devices that can support PLA functionalities.

Funk and McBride (2000) described a number of computer related developments indicating that the technology required for ADL will be in place sooner rather than later. They reported that the pace of development in the computer field, experiencing the effects of Moore's Law, is expected to continue well into the Twenty-First Century. They projected the power of microprocessors to grow another 600 percent between 2000 and 2003, which has turned out to be true. Optical computers, using light rather than electrical pulses, could further boost computing power and bandwidth by several orders of magnitude with prototypes that should be working in the near future. These projections, among others, suggest that the technology required for PLAs along with all other technology required by ADL will soon be in place.

## Sharable Content Objects

Figure 1 illustrates the ultimate organization of ADL based on the above expectations. The cloud on the left side of Figure 1 represents the World Wide Web or whatever serves as our global communication ether in the future. One crucial matter for the implementation of ADL is what has loosely been called 'content' in the form of shareable objects represented by the various icons shown in the cloud. People involved in ADL have spent - and continue to spend - much time, effort, and energy discussing what these sharable content objects (SCOs) should be. That this matter transcends the immediate issues of ADL is evident in discussions by Wiley (2000a, 2000b), Roschelle et al. (1999), Gibbons, Nelson, and Richards (2000), and others.

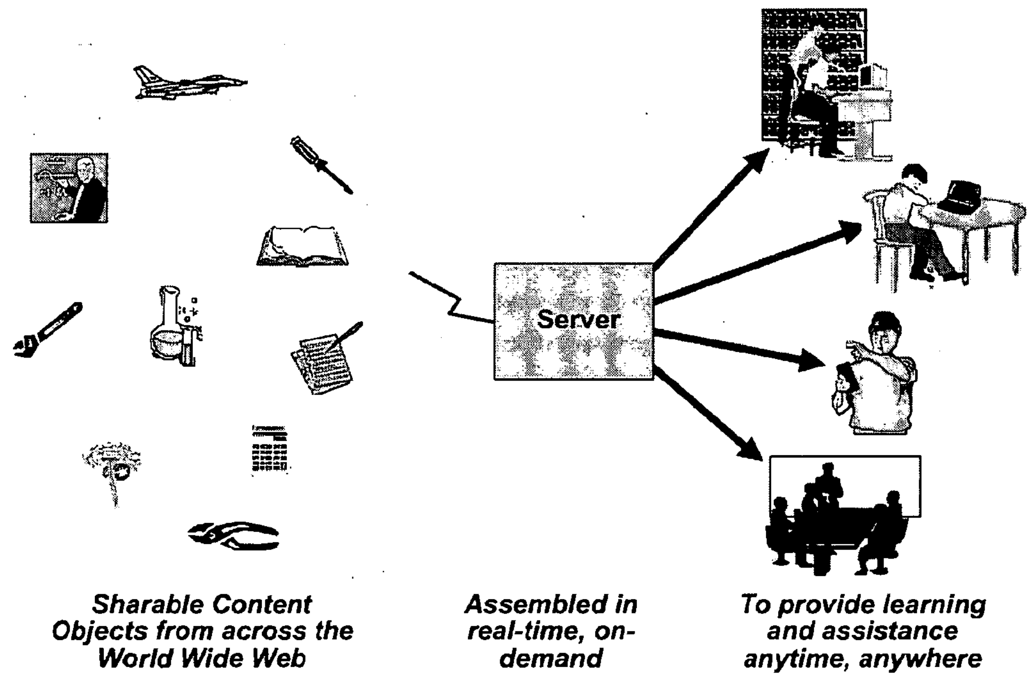


Figure 1. An Advanced Distributed Learning Future.

As presently defined, SCOs could be entire courses, lessons within courses, or modules within lessons. They could be electronic representations, of media, text, images, sound, Web pages, or other data that can be presented to students. They could be material that is not seen by students, but is needed to register them for courses, report on their progress, collect them into classes, or other administrative groupings, assure that rooms of appropriate size are available for the classes, or store data needed to tailor instruction to individual student needs. SCOs could also be content in the form of algorithms that aggregate, integrate, and sequence other objects to manage student progress toward the attainment of specific instructional outcomes.

In this sense, the present discussion of 'content' and what SCOs might be, echoes a controversy that occurred early in the development of digital computers. It concerned the storage of data (traditional content) and logic (algorithms) in different ways and in different locations within the early machines (Goldstine, 1972). John von Neumann recommended storing data and logic together in the same way, as digital bits in a common memory. That settled the discussion and shaped the direction and development of today's computer technology. The nature of SCOs, their disposition, and whether or not to apply a solution analogous to von Neumann's, storing both content and instructional strategies as components to be assembled in learning management systems when they are needed, remains to be determined, but history may repeat itself.

The size, or 'granularity,' of SCOs is also a matter of considerable discussion. Gibbons, et al. (2000) suggested that SCOs will be most useful if they are prepared in sufficiently small size to be accessed and reused by other instructional materials. As suggested by Figure 1, once these SCOs exist, they must be available for assembly, aggregation, and sequencing in real-time and on demand by a server (middle of Figure 1) and then handed to client PLAs (right side of Figure 1).

SCOs have become the foundation for ADL. An important benefit that arises from the availability of SCOs is significantly reduced cost in preparing instruction, performance-aiding, scheduling, and other administrative capabilities for technology-based delivery. This is likely to be true whether the SCOs are assembled in advance by course authors and developers or, as suggested by Figure 1, they are assembled by server algorithms incorporated or imported into learning management systems. In either case, existing, reusable 'chunks' of instructional material will be available for use and will not have to be re-engineered or re-programmed.

ADL development is presently focused on packaging SCOs in anticipation of what has been called by Spohrer, Sumner, and Shum (1998) the "educational object economy." One idea behind such an economy is that the emphasis in assembling materials for technology-based instruction (or performance-aiding) will shift from the current concern with preparing instructional objects to one of integrating already available objects into meaningful and relevant presentations.

ADL developers recognize that software engineering concerns are only a beginning. The primary goal of ADL is not to promote tinkering with software objects but to develop functional capabilities – those needed to produce instructional outcomes anytime, anywhere they are needed or desired. The ADL initiative has made substantial progress at the software engineering level, but it must also address real learning issues - it must determine how to assemble instructional objects to achieve targeted instructional objectives.

These two areas of concern are not independent. They must be coordinated and 'harmonized' to achieve the ADL vision. Designers and developers need some understanding of the underlying ADL architecture and its software specifications if they are to prepare ADL materials that bring about effective learning. Similarly ADL software architects and engineers need some understanding of instructional processes if they are to design objects that can be accessed (or 'discovered'), aggregated, and sequenced to meet specific instructional objectives through the application of specific instructional strategies for specific individuals. Both sides must be involved.

Sharable Content Object Criteria

What then must be done to make courseware objects, both instructional and performance-aiding material, globally available so that they can eventually be assembled in real-time and on demand? What must be done so that they can be found and retrieved from the cloud shown on the left in Figure 1? How should we develop and then store them in Web-based repositories so that they can be identified and used by the full spectrum of instructional approaches in classes or by individuals working alone in educational or training settings? What criteria must candidate SCOs meet? As discussed earlier, four issues seem most prominent and persistent:

1). SCOs must be easily found and retrieved when needed. They must be accessible. Basically, we need widely accepted and standard ways to store objects so that commonly accepted and standard techniques can be used to find and retrieve them - regardless of instructional approach or objectives.

2). Once found, the objects should be usable. This means that they must be interoperable and portable across most, if not all, computer platforms, operating systems, browsers, and courseware tools.

3). When implemented, the objects should continue to operate reliably and be durable despite modifications of the underlying platform software. If, for example, the underlying platform, operating system, or browser is modified (as they are when new versions are released and installed), the objects should continue to operate as before.

4). Finally, SCOs should be reusable. Other platforms, operating systems, browsers, and courseware tools should be able to reuse and modify SCOs as needed.

How can these capabilities be attained? As with many such issues, the problems are as much those of communication, negotiation, and coordination as technology. Software engineers, instructional designers, educators, and trainers in all concerned sectors (industry, government, and academia) must agree on common specifications for developing SCOs and on making them available in the global communications network.

In fact, such agreements have been reached. The ADL SCO specifications are becoming widely used and are being developed as standards by such organizations as the Institute of Electrical and Electronics Engineers (IEEE). Discussions between ADL and such groups are continuing. But achieving formal standards remains a means to an end, not a goal in itself even though a primary ADL objective is to determine what these specifications should be.

Another key ADL goal is to avoid requiring the use of any single, standardized computer configuration, operating system, browser, authoring tool, or programming language. Such a requirement would severely constrain developer efforts to expand the state of the art. Instead, the basic ADL approach is based on a 'virtual interface', a modularized capability that allows developers to do what is best within each module but requires them to observe standardized procedures to communicate between modules, so that they can readily be used by courseware developers, students, and trainees.

This communication is in part made possible through the use of SCO "packaging," which serves as a common approach to provide software wrappers for each module. Packaging describes what is in the module, what resources it requires, property rights concerning its use, and all other information needed to aggregate, sequence, and implement it with other modules into an instructional or performance aiding presentation. Participation of educators is especially important in specifying packaging for instructional objects. They must help ensure that specifications for the packaging of objects will facilitate, if not ensure, accessibility, or 'discovery', by educational programs that need to correctly locate and identify the objects they need both to satisfy their instructional objectives and to match the instructional approach or strategy they are using.

ADL is not, of course, the only activity concerned with such standards. To a significant extent its approach has been to collect and integrate the best work done by other organizations setting standards for software- with their full and even enthusiastic cooperation - into a more comprehensive specification. Particularly notable among these organizations have been the Alliance of Remote Instructional Authoring and Distribution Networks for Europe (ARIADNE) (www.ariadne-eu.org), Aviation Industry Computer-Based Training Committee (AICC) (www.aicc.org), and the Instructional Management System (IMS) Global Learning Consortium (www.imsproject.org). The contributions of these organizations have been supplemented by those from many companies, large and small, that are involved in the design and production of learning and software tools for instruction. Finally, ADL has been supported by non-DoD agencies such as the Departments of Agriculture, Education, Labor, Interior, Housing and Urban Development, and Health and Human Services, in addition to the National Aeronautics and Space Administration, the National Institute for Standards and Technology, and the White House Office of Science and Technology Policy.

The issue presented by ADL turns out to be a 'bootstrapping problem'. We cannot properly design ADL specifications until we understand the full spectrum of what instructional designers and developers will want to do with them, and we cannot understand what designers and developers will want to do until they possess a full spectrum of available software tools. Just as written language and, later, books brought about new approaches to instruction, our computing capabilities will do the same. As these new approaches emerge, our computing capabilities will in turn be shaped to accommodate and support them. The way out of this dilemma seems to be trial and error alternating between one set of constraints and another. The Sharable Content Objects Reference Model (e.g., SCORM, 2001) represents a major foray into this field.

## The Sharable Content Objects Reference Model (SCORM)

To articulate specifications to both software engineers and instructional developers, we need a model to describe them. This model does not replace other models for developing instruction. Instead, it provides a foundation that is primarily used for describing the specifications and how to implement them. For these reasons, the model for developing sharable content objects is called a 'reference model' - hence SCORM or the ADL Sharable Content Objects Reference Model.

SCORM is under continual development, and its most current version can be found at www.adlnet.org. Each release of the model is intended to serve as a stand-alone specification for the development of technology-based instruction. Successive versions build on each other to accommodate a steadily increasing variety of instructional approaches. For instance SCORM Version 1.1 specified object aggregation and the necessary run-time environment for SCORM objects, Version 1.2 specified the meta-data and packaging for SCORM objects, and the soon-to appear Version 1.3 specifies sequencing and navigation for SCORM objects. The evolving SCORM specification allows different authoring systems to produce instructional objects that can be interchanged with other authoring systems and successfully managed by different Learning Management Systems. SCORM provides a rough architecture for what must go into the server shown in the middle of Figure 1.

## The Management of Learning and ADL

The long-range aims of ADL are ambitious with respect to instructional effectiveness and the approaches used to achieve it. As indicated above, ADL's vision is to tailor presentations to the needs, capabilities, intentions, and learning state of each individual or group (e.g., class, crew, team, or staff) of individuals. That vision is similar to the rationale that is usually provided for individualized instruction. Progress in research on adapting instruction to student characteristics, sometimes called aptitude treatment interaction (ATI) research, will have to be made before that goal can be attained.

Reviews of ATI research (Gustaffson & Undheim, 1996; Tobias, 1989; Corno & Snow, 1986) have all reached fairly similar conclusions about the types of interactions between student characteristics and instructional methods that have been verified by research. These reviews suggest that students with either limited prior knowledge of a domain or with lower ability require substantial instructional support (Tobias, 1982) in order to achieve learning goals. Instructional support can consist of features such as: better organization of the content, increased feedback, provision of prompts, hints, and suggestions for those experiencing difficulty with the material, increased opportunities for practice exercises, or review of completed solutions. Students with higher levels of prior knowledge or higher ability usually require less instructional support. Decreasing the level of instructional support generally reduces the time such students need to learn the material and increases the efficiency of their learning activities and efforts.

In short, tailoring instruction to the needs of students transcends issues of aptitude alone. As Tobias (1989) and others have shown, prior knowledge in addition to raw aptitude is an important consideration. Other student characteristics such as motivation, attitude, cognitive style, personality, and metacognitive skills in addition to the constraints and opportunities provided by the learning environment may also need to be taken into account. Much work is needed to achieve ADL goals of generating or adapting instructional presentations in real time, on demand, and tailored to the needs of individual learners.

Adapting instruction to students' prior knowledge is especially appropriate for ADL. Data on other student characteristics, such as their grade point average, intelligence, anxiety, metacogniton, and other characteristics may be obtainable for students in schools but will be unavailable for those accessing ADL instructional objects in other contexts, such as across the World Wide Web, making it difficult to adapt instruction to such characteristics. However, responses made by a student to instructional sequences will provide an increasingly accurate index of the student's prior knowledge of the content to be learned. As indicated below, these responses will form the basis for providing continuous, continuously available, and unobtrusive assessment of each student's progress toward instructional objectives. This assessment will be a prime component of the student model, containing information about mastery of the content and each student's place in the instructional sequence. In these ways adaptations to prior knowledge will become feasible in ADL, even in the absence of explicit tests or data on more traditional individual difference variables.

Toward More Adaptive, Intelligent Learning Systems

Most mainstream learning systems rely on predetermined and often fixed paths to deliver instruction. Such systems lack agility in adapting to learners' mastery states, and are thereby limited in their ability to tailor learning experiences to individual learners. An adaptive, "smart" learning system needs an accurate model of the learner, a model of the knowledge domain, and a machine readable "learning strategy" that can evaluate the differences between the two models. Recent and emerging specifications suggest a means for incorporating more complex behaviors and learner models.

SCORM presently provides a rules-based learning strategy that enables Sharable Content Objects (SCOs) to set the state of global records. These records can store different indices of students' prior knowledge in terms of the learner's degree of mastery in the form of a score, a pass/fail state, or the progress of the learner in terms of completion. A "hook" was included in the records that permits them to reference externally defined competencies. As the learner is sequenced through the SCOs, the learning system builds up a representation of the learner's mastery and progress. The objective records may be viewed as a simple model of the learner's state.

Another emerging specification called IMS Reusable Definition of Competency or Educational Objective (2002) defines a means of building a taxonomy of competency definitions that meet specific objectives. This taxonomy may be organized hierarchically to represent dependencies, supporting skills, or prerequisites. Each competency definition has a text description of the competency and a unique identifier that may be referenced externally. The organization of a competency definition could represent specific skills or knowledge to be acquired for a particular task or subject domain. Because global records in SCORM can reference the competency model identifiers, the means to compare the state of the learner and the desired competencies now exists. This capability provides a system-based means to perform skills gap analysis leading to more sophisticated and adaptive strategies that use such information (Wiley, 2000a, 2000b).

As learning system specifications become more robust, they will also become more adaptive. Improved assessment methods and results are emerging that will better represent the state of the learner. The strategies developed by learning systems will further be informed by learner profile information that can "pre-load" the learner model with mastery information from outside of the system. This process will permit, for example, a learning system to bypass relevant content of pre-mastered material (e.g., holders of certificates in particular subjects) and concentrate on relevant material yet to be learned.

The emerging specifications have enabled a means of representing and tracking the learner that represent external competency/knowledge models. We now have conditional rules that can tailor what the learner experiences to his/her mastery and progress (e.g., Gibbons & Fairweather, 1998). Future services and processes will extend these basic capabilities in more sophisticated and nuanced ways.

Semantic Web and Intelligent Learning Systems

One way the current and near term capabilities of learning systems might evolve is through the Semantic Web, which will provide powerful new technologies for both knowledge representation and the ontologies needed to connect them (Heflin, 2003). These technologies will provide ways not only to relate information but also to draw inferences about logical relations across widely different domains.

The Semantic Web is intended to imbue information available on the Web with sufficient meaning to produce significant improvements in the cooperation between computers and human beings. It requires abstract representation of information on the Web using a Resource Description Framework and other specifications yet to be developed. Dealing with the semantic content of Web pages and information will enhance the process of discovery needed to access relevant information and objects from the Web. Through an ontology, consisting of a taxonomy and a set of inference rules that formally define operations and relations among terms, it will be possible to identify and expose semantic linkages between highly disparate bodies of information.

If successful, the Semantic Web will coordinate real-world knowledge and skills acquired through simulation, education, training, performance aiding, and experience. It will provide a foundation for building more comprehensive and substantive models of subject matter domains and learners' levels of mastery than we now have and combine them with more precise discovery of the instructional objects needed to produce desired human competencies. Learners and practitioners will be presented with a constellation of related activities - learning, doing, trying, referencing. This integration combined with the already available functionalities of generative intelligent tutoring systems – systems that assemble instruction in real time and on demand -- provides the basis for a next generation meta-architecture and learning environments based on instructional objects.

Core components of the Semantic Web will be built on top of existing and emerging Web standards. These standards provide the means to express complex relationships and inference rules that are processed by Web services to perform specific tasks such as profiling learners, representing their skills, knowledge, and abilities, linking these representations to instructional objects, and managing their progress toward objectives and competencies. Web services will serve as reusable, black-box applications that generate other Web-based applications from objects. They will use open Internet standards, such as HTTP (HyperText Transfer Protocol), XML (Extensible Markup Language), UDDI (Universal Description, Discovery, and Integration), and SOAP (Simple Object Access Protocol) to exchange information between applications as needed. The services will be language, platform, and object model independent. They will enable different applications running on different operating systems, developed with different object models using different programming languages to cooperate and become easily used Web applications. They will provide flexible, standards-based capabilities for binding applications together over the Internet, taking advantage of existing infrastructure and applications.

## Instructional Concerns and ADL

A number of issues that have been the subject of research in instructional psychology may be examined from the perspective of their significance for ADL. These issues include research on human and computer tutoring, the effectiveness and cost effectiveness of instruction assisted by technology, and research on distance and Web based learning.

### Tutoring and Teaching

Are the adaptations envisioned by ADL necessary or worthwhile? Bloom (1984) laid down the gauntlet with his 2-Sigma challenge. He combined results from three studies that compared one-on-one teaching (one teacher with one student) with one-on-many teaching (one teacher with a classroom of 25-30 students) and found a difference in student achievement between these two approaches amounting to two standard deviations - or two sigmas. This difference is roughly equivalent to raising the achievement of 50th percentile students to the 98th percentile, clearly a dramatic increase in level of achievement. Other reviews of tutoring (e.g., Cohen, Kulik, and Kulik, 1982) have produced similar results.

More recent research has suggested the basis for these findings. One possible source appears to be the intensity of interactions, measured by questions asked and answered, in tutoring. Another may be the ability of individualized tutoring to overcome the substantial spread of ability, measured by time to criterion, typically found in one-on-many classroom instruction.

Supporting the first possibility, which arises from the intensity and frequency of student-teacher interactions, Graesser and Person (1994) compared questioning and answering in classrooms with those in tutorial settings. They found that classroom groups of students ask about three questions an hour and that any single student in a classroom asks about 0.11 questions per hour. By contrast, results indicated that students in individual tutorial sessions asked about 20-30 questions an hour and were required to answer 117-146 questions per hour.

Are findings such as those reported above echoed by ADL technologies? Early applications of computer-based instruction in the 1960s found that kindergarten through third grade students in mathematics and reading were responding to 8-12 questions a minute despite the fact that they were using slow 10-character a second teletypewriters (Fletcher, 1979). Other forms of computer-based instruction such as intelligent instructional systems (Woolf & Regian, 2000) allow mixed-initiative dialogue in which students formulate and ask questions of their own devising. Data on the frequency with which they do so are not easily found, but these systems can clearly receive and respond to many more than 0.11 student questions per hour. The intensity of interaction enabled by tutorial settings, supported either by human or computer tutoring, may well be one source of the large differences in achievement found between tutorial and classroom based instruction.

A second possible source of the differences between tutorial and classroom instruction may be the ability of one-on-one, individualized tutoring to adjust the pace of presentations to student needs. Such adjustments allow instruction to accommodate the amount of time different students need to achieve the same instructional objectives. That these times differ is a commonly noted problem for classroom instruction. What is not so commonly noted is the extent to which the time needed to learn differs. Gettinger and White (1980) found that the times fifth grade students needed to master a unit of social studies varied by 3:1 and 5:1. Suppes, Fletcher, and Zanotti (1975) found that the ratio of time needed by hearing impaired and Native American students to reach mathematics objectives to be 4:1. Carroll (1970) estimated that, overall, the ratio of times needed by elementary school students to reach given objectives to be 5:1. Corbett (private communication, 1998) reported that the ratio of time needed by undergraduates in a major research university to learn features of the LISP programming language was 7:1. Doubtless these ratios are due to a number of factors, but as Tobias (1989) suggested, prior knowledge appears to be a major factor, one that quickly overtakes ability in accounting for the speed of learning.

Conscientious classroom teachers, wishing to leave no student behind, must typically make time for their slower-learning students to catch up with the rest of the class. Individualizing the instructional pace through the use of either human or technology-based instruction should reduce the average time groups of students need to reach common objectives. In investigating this possibility Fletcher (2002) reported that across 65 assessments comparing time to learn in classrooms with time to learn using technology, time savings seen in the technology-based instruction settings generally amounted to about 30 percent -- even without any particular effort to reduce instructional time. When a concentrated effort is made to reduce time to train, as for instance Noja (1987) has done, it is not unreasonable to expect reliable time savings of 50 percent. In short, individualized learning environments stimulate more interactions with students, save instructional time, and can substantially enhance learning.

Why then don't we simply use human tutors to provide one-on-one individualized instruction to all our students? The answer is as obvious as it is simple, we cannot afford it. As Scriven suggested some time ago (1975), even though individualized instruction is an educational imperative, it is also an economic impossibility. By using technology in general, and ADL in particular, to emulate the advantages of one-on-one teaching, individualized instruction, or something close to it, may well have become affordable. By taking advantage of the World Wide Web, as ADL does, we may make individualized instruction not only affordable, but globally accessible - providing a tutor for every learner anywhere, anytime.

Technology and Instruction

The values of ADL technologies are as likely to be economic as pedagogical. Progress in the areas of computer based education (Gibbons & Fairweather, 2000), intelligent tutoring systems (Woolf & Regian, 2000), along with our increasingly sophisticated understanding of learning and instruction in general (Tobias & Fletcher, 2000) and individualized instruction in particular (Shute, Lajoie, & Gluck, 2000) suggests that these aims of affordability, individualization, and accessibility are achievable.

Eventually, ADL technologies will not simply mimic what classroom teachers can do to adapt instruction to the needs of individual students. Instead, they may add different and powerful capabilities that supplement what master tutors and instructors now do to create effective, engaging learning environments. As in most technological developments, we may begin with an analogy based on current practice - mimicking the individualizing practices of human teachers -- but finish with something entirely new and unexpected. Clearly, ADL is not intended to supplant or mimic teachers, but rather to enhance their capabilities. It seems worth re-emphasizing that contributions by educators and educational researchers are essential to ensure that issues dealing with instructional effectiveness and the adaptation of ADL objects to student characteristics and needs are addressed.

Given that ADL technologies can supply some ingredients of tutorial instruction by adjusting the pace of instruction to the prior knowledge, abilities, and/or needs of students and by increasing the interactive intensity of instruction, the question of instructional outcomes remains. Are outcomes from technologically assisted instruction at least as good as, if not better than, what we now provide in classrooms? Reviews by Kulik (1994), Fletcher (2002), and many others have found significant improvements in knowledge and skills gained through the use of technology-based instruction. These improvements have not yet reached the 2 sigma level, but improvements approaching 1.00 standard deviations are not uncommon, and some assessments (e.g., Gott, Lesgold, & Kane, 1996) have reported improvements in excess of 2 Sigma.

Another question that might be asked is most relevant to education decision makers. Improved instructional effectiveness is fine, but the question for decision-makers, as for administrators, is what must be given up to get it? In other words, what is the cost-effectiveness of these ADL technologies? Fletcher, Hawley, and Piele (1990) used data reported by Jamison et al. (1976), Levin, Glass, and Meister (1987), and their own studies to assess the costs needed to achieve a common instructional outcome, raising student scores on a standard test of mathematics comprehension by one standard deviation. In this way, they compared the costs (constant and adjusted for inflation) and effectiveness of tutoring by professional tutors, peer tutoring, reducing class size, increasing instructional time, and using computer based instruction. Their results suggest that the most cost-effective approaches among all these alternatives are computer-based instruction and peer tutoring. They also suggest that, of the two, computer-based instruction is more cost effective. This result echoes the findings of Niemiec, Sikorski, and Walberg (1989) who compared studies on the costs and effectiveness of peer tutoring with studies of computer-based instruction. They found the two approaches to be equally effective (and more effective by about 0.4 standard deviations than conventional classroom instruction). Further, they found clear cost-effectiveness superiority (by a factor of about three) for computer-based instruction over peer tutoring.

It is notable that peer tutoring and technology-based approaches are not incompatible. A strong cost-effectiveness argument can be made for combining peer tutoring with computer based instruction. Such a combination may be accomplished by presenting instruction to more than one student at a time on a single computer station. This sort of approach has been shown to be effective some time ago by Grubb (1964) and more recently by Mevarech (1997) and Rush (1997).

Distance Learning, Internet Based Instruction, and ADL

The research summarized above suggests that use of the technologies on which ADL is based reduces the cost of instruction by about one-third and that it either reduces time of instruction by about one-third or increases the skills and knowledge acquired by about one-third. Questions then naturally arise about the other aspect of ADL - delivering instruction using the World Wide Web. While an increasing amount of instruction, both training and education, is delivered over the Web there is unease about its quality, a concern summarized by Woolf and Regian:

> "Few Web-based educational systems customize material to meet individual need. Most offer a simple relatively ineffective selection of text and graphic elements that provide only impersonal activities with limited interactivity. Many allow students to navigated freely among pages of text or multimedia, with little basis in sound pedagogy, monitoring, tracking, or personalization" (2000, p. 352).

It is unclear how widespread these concerns are. There is relatively little empirical research dealing with the effectiveness of instruction delivered over the Web (Olson & Wisher, 2003). Nonetheless, it is important for instructional designers to be aware of these issues while preparing Web-based instruction whether they use ADL objects or not.

Woolf and Regian's concern with the "sound pedagogy, monitoring, tracking, and personalization" that are crucial components of the ADL initiative contrast with the less interactive, agile, and flexible technologies such as video teletraining, video conferencing, instructional radio, paper-based correspondence instruction, and instructional telephone commonly used in distance learning. In general, the distance learning studies using these technologies find that the instruction they provide is about as effective as residential classroom instruction, less preferred by students, but notably less costly. For instance, Russell (1999) identified 355 studies reporting no significant differences between distance education and other instructional modes. His findings are confirmed by other researchers (Lockee, Burton, & Cross (1999); McIsaac & Gunawardena, 1996; Phipps & Merisotis, 1999). Bernard, Lou, and Abrami (2003) conducted the most comprehensive meta-analysis of distance learning. Their report reviewed 157 studies involving 45,495 students and found a small, though significant, achievement effect favoring distance education. It remains worth noting that if the research finds equal effectiveness, the lower costs of distance education then suggest its superior cost-effectiveness to residential, classroom instruction.

Research comparing distance education with residential classroom instruction may not be particularly relevant in assessing the effectiveness of ADL. These studies typically concern whole courses delivered using the somewhat more constraining technologies of distance learning. In addition to its greater individualization and interactivity, the most promising role of ADL for education may not be as a substitute for current instruction, or any other form of future teaching that assumes the whole instructional burden, but to augment existing instructional practices.

ADL and Educational Practice

Our late colleague Richard E. Snow once remarked that research on educational innovations often seems to be little more than a random walk through the panacea garden. With that wise comment in mind, we emphasize that ADL will not solve all educational problems. Unlike many other educational innovations, one important advantage of ADL is that it can be minimally intrusive with respect to the organization or culture of any school. In addition to being platform independent, i.e. operating across many different computer systems, ADL capabilities are also independent of the organizational arrangements or instructional program of school systems and even classrooms. ADL objects can be used as easily by students working in one of the emerging types of classroom organizations advocated by social constructivist and situativity theorists (e.g., situated and collaborative learning, facilitating communities of learners; Greeno, Collins, & Resnick, 1996; Brown & Campione, 1990, 1994; Duffy & Jonassen, 1992) as they can by other learners in relatively traditional classrooms working largely under teacher direction.

We envision many educational environments in which accessible ADL instructional objects can significantly improve instruction. For example, a student may need to solve a problem in a class organized to facilitate forming communities of learners (Brown & Campione, 1990, 1994). In that setting, students could use ADL objects to solve one part of a larger problem working alone or in a group, and then report the results back to the whole class. Similarly, instructional objects could be used by students working on problems posed in anchored instructional arrangements using the Jasper Woodbury videodisc materials (Cognition &Technology Group, 1995), in goal based scenarios such as those developed by Schank (1997), or in any one of the variety of case based learning formats described by Allen, Otto, and Hoffman (2000). Such courses are similar to those given over the Internet in which students work on lessons independently and are free to use any materials to help them accomplish course objectives. Of course, ADL objects could also be used in courses delivered over the Internet. As Duffy and Kirkley (in press) reported, use of the Internet for instruction is an area primed for dramatic expansion in education.

It is just as easy to imagine the use of ADL objects in relatively traditional educational settings. For example, an instructor could assign an object to a whole class of students to help them solve a problem. Students could work on the problem as a group in class, or they could do so singly by themselves as seatwork in school, or work on it after class or at home as a research activity or homework assignment. Similarly, ADL instructional objects could be referenced in curriculum guides, workbooks, and teacher's editions of textbooks in order to complement various instructional presentations. Instructional objects could be used on-line or off-line, alone or in classes organized according to a variety of instructional principles and approaches.

Wide use of ADL objects in school settings pre-supposes that their instructional utilities are known. But even when they are not, the objects can be used in schools while research continues to solve these problems. Computer based education found applications in schools before definitive evidence of its usefulness was developed (Tobias, 1985), and the instructional arrangements favored by social constructivists are being implemented while evidence of their effectiveness is being accumulated (Greeno et al., 1996; Duffy & Cunningham, 1996). As ADL instructional objects become ubiquitous in business, industry, the government, and the military, they will be similarly used in schools while research dealing with their effectiveness and applicability continues.

Teachable Moments

One attractive aspect of ADL instructional objects is that students will be able to retrieve them at a time when their curiosity about a problem has been aroused, or at a "teachable moment." Such moments may be generally defined as occasions when students are ready to learn by creating or taking advantage of a stimulating environment. Teachable moments are described in the literature dealing with a variety of educational contexts such as: the education of pre-service teachers (Jones & Vesilind, 1996), mathematics education (Mewborn, 1998), sex education (Haffner,1999), skills instruction in language arts (Hinchey, Adonizio, Demarco, & Fetchina, 1999), and instruction dealing with equity considerations in educational administration (Scolay, & Logan, 1999), among others.

ADL objects are likely to be used in educational contexts taking best advantage of teachable moments, irrespective of the instructional program employed. The availability of instructional objects to help students solve problems that have aroused their curiosity, and the probability that the objects will make it easier for students to complete their schoolwork anytime and anywhere are likely to make them as ubiquitous in educational settings as they are becoming in training contexts.

Articulation Between Technologically Mediated and Classroom Instruction

We have emphasized the many favorable outcomes likely to occur from a learning capability that is accessible anytime, anywhere - one that provides an Aristotle for every Alexander, an Anne Sullivan for every Helen Keller, and a Mark Hopkins for the rest of us. We have suggested that the appearance of such a capability is effectively inevitable. We also note that the appetite for this capability is growing, just as the appearance of printed, relatively inexpensive books raised the appetite of the European middle classes for reading and learning. Today's heavy use of Web search engines, which appear to be the primary source of Web-based learning, may be analogous to the popularity of affordable printed materials when they were first introduced.

In order to prepare adequately for the impact of ADL on education, it seems important for both publishers and providers of educational software to anticipate the wide scale uses of instructional objects in the curriculum. Such awareness has two important advantages for these groups. First, integrating their products with freely available ADL instructional objects will enrich their instructional offerings without increasing their cost. Second, the objects can carry part of the instructional burden, making it possible to shorten and simplify some of the educational materials prepared for delivery.

To some extent this integration is occurring. Internet based materials are being introduced by existing K-16 educational institutions whose mission is to ensure the development of an educated populace. This practice will introduce challenges of its own. What will become of these institutions as the flood of Web-based resources and its life-long, technology-based learning capabilities become increasingly prevalent? Educators and educational institutions must rise to meet these challenges. Furthermore, no one can claim full knowledge or complete understanding of these issues. We need to promote and nurture open and vigorous discussion between individuals developing ADL technologies and the educators who are affected by them. Topics for this discussion might, for example, include life-long learning, certification, equity, and privacy.

Life-long Learning and Certification. An attractive attribute of ADL is that it can make lifelong learning a reality. At a time when large segments of our population are of retirement age, many members of that vast group may wish to learn subjects without necessarily committing themselves to formal courses either in educational institutions or by registering for Web based offerings. For these individuals, accessing ADL instructional objects is a convenient way of availing themselves of such instruction without having to commit to an instructional program, or even a single course.

With life-long learning both increasingly necessary and available in a rapidly evolving world of instruction assisted by technology, what does it mean to be educated and where does the responsibility lie for ensuring an educated populace? Currently we expect educators and our K-16 educational institutions to perform the roles and fulfill the responsibilities needed to ensure necessary, certified levels of education in our population. With learning available anytime and anywhere, students who have attained knowledge, skills, or abilities without the benefit of classroom instruction, formal certification, or a credential, will want to receive credit for these competencies and have them integrated into subsequent programs of study. These concerns should be addressed before students or employers become discouraged with educational systems that increasingly seem inflexible and unresponsive to student accomplishments and needs.

Educators have ensured that an 8th grade, high school, or college education has reliably produced a level of learning allowing graduates to function as capable citizens. But with instructional resources that allow students to determine their own educational objectives and to achieve them anywhere, anytime outside of formal educational institutions, how will educators ensure that students will be motivated to pursue certified educational standards in schools? How will they ensure that students capable of pursuing higher levels of schooling will be motivated to do so? What responsibility will they assume for the life-long education, certified and otherwise, of students who have graduated? Clearly, thought must be given to problems of articulation between technologically mediated instruction available to anyone, anytime, anywhere and school offerings leading to a credential.

To some extent educators have begun to absorb ADL capabilities into their current operating procedures. As suggested above, such absorption is not only possible but also fairly easy to accomplish. However, our current instructional procedures were developed over many years with considerable thought and care given to classroom formats in which instruction is conducted at specific times and places, in specific subject areas, for students grouped into age cohorts. Such educational offerings have curricular objectives intended to be completed at about age 18 for those who will not complete college or by students in their mid-twenties for those who do.

ADL and other forms of technologically mediated instruction are creating a future in which life-long, individualized, student-controlled, inexpensive, and easily accessible learning is available. Such instruction may differ dramatically from traditional offerings suggesting that instructional procedures developed for classrooms may have to change and adapt in far more fundamental ways than we currently imagine. Similarly, in the United States control over the content of instruction is usually exercised locally at the state, city, or county level. With the advent of newer instructional delivery systems, educators in all these levels must be intimately involved in the design and implementation of articulation measures with respect to curriculum, credentialing, and the instructional procedures used in classrooms.

The rapid growth of instruction delivered over the Web has been mentioned above. In the public sector, that growth has created problems dealing with the compensation and teaching load of faculty who develop such courses. These problems are usually settled at the local level. It may be expected that the wide scale implementation of ADL will increase these concerns. These problems have to be addressed by educators if learning, in and out of class, is to function smoothly. The most significant challenge for educators may not be the technology itself, but identifying and making the organizational, budgetary, and structural changes needed to capitalize on this technology and avoid being sidelined as its use progresses.

Equity and Privacy Concerns. Equity concerns will also have to be addressed once ADL is introduced into the schools. It is well known that children from poor and minority backgrounds, whether in urban or rural areas, have less access to technological devices supporting instruction than their wealthier peers (Department of Commerce, 1999). It has also been shown (Lazarus & Mora, 2000) that there is lack of equity even in the content available for access by technology. Until PLAs are introduced this so-called "digital divide" will make it easier for more affluent children to access ADL instructional objects than for their less affluent peers. Once PLAs are introduced, this divide is likely to be reflected as well in the number of such devices accessible to students from differing socioeconomic backgrounds, and thought will have to be given to take steps to reduce the digital divide.

The capability of PLAs to store an increasingly comprehensive model of each individual's knowledge and skills and to build, verify, and modify such a model continuously and unobtrusively, raises further issues for educators, developers of ADL, and the public in general. How will individual privacy and data security be sustained if each PLA can be queried, anytime and anyplace, to determine each individual's level of skills, knowledge, and abilities - among other things? Both educators and developers of training materials for the public sector will have to address the privacy issues. In addition, educators will need to develop plans for harmonizing this knowledge about students with their responsibility to certify educational standards and levels of academic achievement.

These comments identify only a few of the challenges (and opportunities) that technologically mediated forms of instruction pose for education. This discussion is certainly not comprehensive and other concerns can easily be listed. We expect that once educators begin to envision a future that includes ADL they will begin to identify and address the many issues that will arise. We hope that mentioning a few of them here and now will enable, motivate, and encourage educators, educational administrators, planners, leaders, and researchers, as well as an informed citizenry to begin to develop plans for dealing with them.

## Conclusion

We have described the ADL initiative and its implications for education, training, and performance aiding (or performance support) We have discussed some implications of ADL for these applications and suggested that it will have significant effects on the practice of instruction. It is important for educators to become aware of ADL's potential to augment instruction in schools and that they participate in ADL development, in creating courseware objects, and in developing guidelines for educational implementations. Finally, it is important that plans for the future of schooling are informed regarding the potential of ADL to augment the way students will be instructed in the future, both in and out of school. Proactive involvement of educators and educational researchers in these activities will enable them to shape development and implementation of ADL and other forms of electronically mediated instruction for use in schools and in society at large. We hope they will choose to capitalize on the opportunities offered by ADL capabilities and participate in their development. If they do so, all of us with a stake in human learning, knowledge, and performance will benefit.

**A Glossary of Terms**

ADL (Advanced Distributed Learning). An interactive, technology-based capability for making education, training, and performance aiding accessible anytime, anywhere.

ATI Research (Aptitude Treatment Interaction Research). The research base for adapting instruction to differences in <u>any</u> student characteristic; not limited to traditional aptitudes and may include anxiety, metacognition, motivation, etc...

Authoring System. A capability for entering and storing instructional content and teaching strategies in a technology-based learning system.

Browser. A program used by a client for interfacing with the World Wide Web, requesting information from a server, and then displaying the information provided in response to the request.

Client/Server: A network in which one computer, the server, provides the information, files, Web pages, and other services to an individual computer program or personal computer, the client, that accesses it. Typically, more than one client may log on to the server at the same time.

Distance Learning. A capability for providing education and training to individuals in ways other than face-to-face meetings between individual students, student groups, or instructors.

Distributed Learning. A capability for providing education and training, anytime and anywhere.

HTTP (HyperText Transfer Protocol). Establishes basic communication procedures for clients and servers intending to use the World Wide Web.

Individualized Instruction. Education and training that is tailored to the needs, objectives, and characteristics of the learner. In technology-based instruction the tailoring is accomplished on-demand and/or in real-time.

Instructional Objects. Self-contained instructional modules assembled by computer to provide education, training, or performance aiding.

Instructional Support. The assistance given learners to help them master instructional material. It may consist of features such as: better organization of the content, increased feedback, provision of prompts, hints, suggestions, or practice exercises.

Learner Model. A model of the students' present state of knowledge and skill. It is created by a learning system that collects data to create a representation of the learner's level of mastery and progress.

Learning Management System. Software (or 'middleware') that controls education, training, and performance aiding events through the retrieval and management of instructional objects to achieve instruction or performance objectives. Provides instructional services such as registration, maintenance of learner profiles, access to system resources, data recording, and reporting.

Learning System. A technology-based system that includes instructional material and routines to manage presentation of the material by adjusting content, sequence, style, difficulty, etc., and to monitor, record, and report student progress toward instructional objectives.

Metadata. Data about data. Metadata describes the content, quality, condition, and other appropriate characteristics of data so that potential users (including computer programs) can find the content they need for an application. Metadata is part of the packaging of an instructional object and may include information on intended students, prerequisites, instructional objectives, format, what the object replaces or is replaced by, copyright information and access rights, when the object was created, modified, or last used, and so forth.

Mixed Initiative Dialogue. Person-to-computer interactions that allow either the computer or the person to initiate the interactions, which frequently, but not necessarily, consist of questions and answers.

Ontology. A description of concepts, the relationships that can exist among them, and relationships with other similarly described concepts. Ontologies are designed to enable knowledge sharing, reasoning, and reuse across multiple, and perhaps quite different, subject areas.

Operating Systems. An organized collection of mid-level services that control and manage basic computer functions such as processor operations, memory management, input-output devices, Internet and Web communications, file and directory systems, command languages, and user interfaces for invoking and managing higher level application programs such as word processors, data base managers, and computer-assisted instruction.

Performance Aiding. Technology providing the information a user needs to perform a task or solve a problem. The objective in performance aiding is not to effect a change of behavior, as in learning, although that may be an incidental result of performance aiding.

Personal Learning Associates (PLAs). Portable or wearable electronic devices that use wireless communication to assemble learning and performance aiding presentations on demand and in real-time from Web-accessible objects -- any time, anywhere.

Platform-Independent. Capable of operating on any computer system, e.g., Windows, Mac OS, Linux, etc. and across any browser.

SCORM (Sharable Content Objects Reference Model). Provides the foundation for specifying the development of reusable instructional objects along with their implementation and use.

Semantic Web. An extension of the current World Wide Web in which areas of content are given well-defined meaning and in which applications are integrated using specified processes for naming and describing relations among them.

Sharable content objects (SCOs). Instructional objects. SCOs may contain entire courses, lessons within courses, modules within lessons, or consist of electronic representations, of media, text, images, sound, Web pages, or other data to be presented to students. They may be material that is <u>not</u> seen by students, but is needed to register them for courses, report on their progress, collect them into groups, or store data to tailor instruction to individual student needs. They may also be content such as algorithms that aggregate, integrate, and sequence other objects to manage student progress toward instructional outcomes.

SOAP (Simple Object Access Protocol). An XML based protocol for exchanging information in a decentralized, distributed environment.

UDDI (Universal Description, Discovery, and Integration). A Web meta-Service that locates other Web services by matching free-form inquiries with service metadata.

Virtual Interfaces. Standardized procedures to facilitate communication between instructional modules, making them usable and reusable by courseware developers, students, and trainees, while leaving developers free to do what is best within each module.

World Wide Web. A client-server model for networked computer systems using Internet protocols. Interactions between clients and servers are enabled by HyperText Transfer Protocol (HTTP) to establish communication procedures and HyperText Markup Language (HTML) to describe how content, the Web documents, are to be displayed.

XML (Extensible Markup Language). A simplified form of Standardized General Markup Language (SGML) that allows its extensions to be interpreted by Web browsers. A markup up language is used by document preparers to embed instructions for printing and displaying a document, information about components of the document, markers indicating the meaning of portions of the document, and other non-displayed comments.

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