1998 Learning Technology Research Report

By ASTD Research

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The supply of workplace learning

The same technology that is revolutionizing work holds the promise of revolutionizing learning, as well as how learning and work occur together. To date, most of the discussion and excitement about learning technologies have centered around how these technologies can make learning available anytime, anywhere, in any amount, and at a lower cost. Although these benefits do make the administration of learning programs significantly easier, they do not begin to scratch the surface of what the learning technology revolution has to offer. Learning technologies hold the promise of forever altering the process of learning.

If today's multimedia course designers simply digitize the same information that used to be delivered by live instructors, then an incredible opportunity will be missed. Making information available anytime, anywhere, in any amount, and at a lower cost is only an extension of a 15th-century revolution called "the printing press." Gutenberg's printing press, in combination with an acceptance of the vernacular language, gave people the same benefits being touted today as benefits of the learning technology revolution. When compared to the average online courses available today, books are no less accessible or interactive. Learners can control how much of a book to read, when to read it, and who to read it with. They can also pick up a phone and discuss the book with another learner anytime they want to.

Learning has interesting parallels with the scientific principle of entropy. The entropic principle states that matter, which is composed of molecules, will constantly seek a simpler and simpler form. In other words, things will disintegrate continually over time because they are composed of molecules that want to return to their original form. Although we are inclined to believe that technology has opened the floodgates of information, it is really a natural occurrence that has been gaining momentum for at least 800 years. Technology has only provided a vehicle for transporting the information to individuals.

Today's technology can enable learners and educators to finally break free of the "teaching by telling" paradigm. As Don Tapscott comments in his book *The Digital Economy*, network computing now makes it possible to "customize down to the individual." Just as products can now be easily customized, learning can be customized to fit an individual learner's needs and interests. Rather than have professional educators assemble information into "topic packages," they will break down information into learning molecules--learning objects–that learners can reassemble and order based on critical their thinking skills and levels of understanding.

In *The Digital Economy*, Tapscott enumerates these Six Themes of the New Learning:

1. Increasingly, work and learning are becoming the same thing.
2. Learning is becoming a lifelong challenge.
3. Learning is shifting away from formal schools and universities.
4. Some educational institutions are working hard to reinvent themselves for relevance, but progress is slow.
5. Organizational consciousness is required to create a learning organization.
6. The new media can transform education, creating a working-learning infrastructure for the digital economy.

Themes 1, 2, and 6 are particularly relevant to the profession of training and development. The job of learning professionals is to devise innovative ways to help learners find and assemble information, to offer learners important questions to consider, and to make the process of self-discovery more efficient and practical. Today this is more important than ever, as we strive to keep pace with the unfolding knowledge era and with global competition. As stated by J. Rosow and J. Hickey in their book *Strategic Partners for High Performance: Part 1:* "Knowledge capital represents the only remaining source of competitive advantage for organizations. Most other major com ponents of competitiveness are universally available: Natural resources can be bought, capital can be borrowed, and technology can be copied. Only the people in the workforce, with their skills and commitment, and how they are organized, are left to make the difference between economic success and failure."

Four key developments in learning technologies
The fast-expanding digital realm is creating all manner of new efficiencies in the way companies manage their businesses--including a growing emphasis on technology-delivered training. Four developments in the learning technology arena promise to accelerate the trend toward technology delivered training.

Training professionals who have been struggling to keep pace with the state of the art in learning technologies are as likely to be as frustrated as any other manager coping with the digital revolution. As many have come to realize, the task calls for much more than tracking a moving target; a better analogy would be surveying a fast-growing bubble whose surface represents the latest information technologies. As the bubble expands, the scope of technologies grows exponentially.

To help filter the burgeoning array of technology contenders, we've identified developments in four specific areas that promise far-reaching impact in the learning technology arena. One of the four, the Internet, comes as no surprise. But its growth in the last two years has outpaced even the most ambitious forecasts, and its impact on the business community at large and the training field in particular continues to be underestimated.

The second technology, intelligent tutoring systems, is an approach to training delivery that has been brewing in federal and university research labs for decades, but has recently begun to benefit from advances in artificial intelligence and other areas.

Object-based learning, the third topic in this section, is a corollary to the field of object-oriented programming that may usher in a new paradigm in the way learning is organized, delivered, and stored.

Finally, voice recognition technology, heralded in recent media reports as "ready for prime time," is beginning to be harnessed in ways that enhance interactivity with learning technologies and that free workers from their keyboards.

Each of these technologies is in a different stage of evolution, but all appear likely, if not certain, to widen the boundaries of technology-based training. Following are overviews of each technology, including current capabilities and development trends, early application examples, and forecasts from experts on their future impact.

The Internet. The migration at many large organizations to Internet-based training (IBT) is already well underway--whether by harnessing the data network as an economical distribution mechanism for computer-based training, as an electronic "correspondence course" approach, or as a platform for interactive multimedia CBT. But the growing momentum of Internet-based commerce in general and IBT in particular is astonishing if several recent forecasts are borne out.

In its most recent study of Internet-based training in the United States, International Data Corporation, an Internet market research firm, forecasts an explosive growth of IBT in the information technology arena over the next five years. IDC estimates that IT-related IBT accounted for $197 million in 1997, a figure that will surge to more than $5.5 billion in 2002--a compounded annual growth rate of nearly 95 percent.

"What we're seeing is a maturation of IT infrastructures to accommodate Web-based training, high interest among companies to pilot online learning systems, and a growing pool of knowledge on how to go about it successfully," says Ellen Julian, IDC's research manager for education and training markets and author of the study, *Emerging Market for Web-Based Training 1996-2002*, published by the Framingham, Massachusetts-based company in March 1998.

"We're entering the steep part of the growth curve," says Julian, citing a large influx of start-up companies entering the market and the stirrings of a merger-and-acquisition frenzy among the larger players. Continuing technology enhancements are fueling interest in IBT options, she adds. "Just two years ago, email chat was the state of the art in instructor-led IBT," she notes. "Now companies are implementing live, real-time videoconferencing and collaboration over the Internet."

"But it's not just the technology; it's the smarts around taking the technology and putting it to effective use that is aiding IBT growth," says Julian. Her study states that market growth will be hastened by a shift from hybrid approaches such as Web/CD-ROM to purely Web-based delivery and an expansion of value-added services from IBT providers and consultants.

Technology consultants The GartnerGroup sees growth of the Internet in terms of a "cyclonic convergence" of Internet-related technologies and content that will yield a new "networked information era." Says the Stamford, Connecticut-based IT research and consulting firm, "The Internet-enabled networked information era will occur by 2003, when the majority of the world's information (such as published content) is created, stored, revised, published, archived, and integrated digitally and available instantaneously through electronic transmission."

The Internet is fast becoming entrenched in the daily lives of many, which will encourage its use as a training medium. A June 1998 survey of Internet use by the Pew Research Center found that one in five Americans access the Web for news at least once a week, nearly quadruple the number from a similar survey just two years ago.

Indeed, market analyst Forrester Research is forecasting a growth in electronic commerce over the Internet from roughly $22 billion this year to an estimated $350 billion by 2002, reflecting the growth of both business-to-business transactions and sales to consumers.

The Internet's impact on commerce is being felt in international markets as well. IDC predicts a surge in e-commerce in Asia-Pacific markets, including a jump in total Internet-related commerce from $1.93 million in 1996 to $1.04 billion in 2001. A swelling of the installed base of Internet-capable computers and service providers will fuel the increase. Analysts expect to see the number of users accessing the Web in Asia-Pacific to grow from 25.6 million at the end of 1996 to 71.3 million by the end of 2001.

As the number of people using computers and accessing the Internet continues to grow, new levels of familiarity and comfort with these technologies will be inevitable. Such familiarity will further open the door to IBT, as evidenced by the dramatic growth of online educational institutions, such as the British Open University and the University of Phoenix, which has grown from fewer than 10,000 students in 1990 to nearly 50,000 in 1998.

Those rosy forecasts of continued Internet growth are being tempered in some quarters by growing concerns over the ability of the data network that underpins the Internet to keep pace with usage. Although data-compression techniques and infrastructure upgrades are yielding improvements in the volume of content that training providers can distribute over the Internet, some analysts see a coming bandwidth crunch and ominous scenarios.

In a commentary in *ComputerWorld*, IDC senior vice president John Gantz warns that, based on IDC's demand forecast, Internet lapses are inevitable in the short to medium term. "When you do the math, bandwidth demand grows from about 200 trillion bits per day (BPD) in December 1996 to 9,000 trillion BPD in 2001 and 220,000 trillion BPD in 2006." Says Gantz, network brownouts will likely become more frequent as network providers struggle with those exponential increases.

Robert Metcalfe, who invented Ethernet network technology, has predicted that the Internet will collapse as a result of excessive volume before capacity can be upgraded. Thus far, two of Metcalfe's predicted "gigalapse" deadlines have passed without such a catastrophe.

The U.S. Department of Commerce has sounded its own warning over Internet stability as a result of spiking usage rates. In an April report, *The Emerging Digital Economy*, an otherwise upbeat assessment of the Internet's role in global commerce hinges on the ability of telecommunications providers to upgrade their capabilities. "Greater competition in telecommunications and broadcast industries should be encouraged so that high-bandwidth services are brought to homes and offices around the world," the report states.

ITS in the Field: US WEST

The Defense Department isn't the only game in town in terms of ITS development. A system developed and implemented at telecommunications provider US WEST is often cited as evidence of the technology's promise. The Learn, Explore and Practice ITS project was developed by Charles Bloom of the Boulder, Colorado-based firm's technical staff. LEAP harnesses several features that distinguish ITS from standard CBT, with the exception of voice recognition technology, still primitive when LEAP was developed in 1992.

"LEAP is a computer-based interactive learning environment that accurately emulates the work environment of a customer contact employee and is capable of intelligently coaching users in how to perform that job," says Bloom. The system provides users with realistic learning activities in the form of scenarios to practice, coaching assistance as needed or requested, proactive instructional strategies, and opportunities to reflect on performance at the completion of each scenario. LEAP's performance, including detailed studies comparing it with other training interventions aimed at the target audience, is well documented in the ITS research community, including a review of the project in a 1996 compendium of ITS research, *Intelligent Tutoring Systems* (Springer-Verlag, 1996).

"To create an interactive instructional environment for the customer contact job requires the ability to simulate customer contacts--the milieu in which a customer contact employee works," says Bloom. The system does that by using pre-recorded simulated customer calls and by recording how the employee responds. The recorded response is then compared to a model response that learners use to identify errors or skill gaps. Similar to other ITS systems, LEAP appraises an employee's skill level and selects training material based on the assessment. The student model is used by LEAP to make inferences about a user's various skill levels and maintain a record of items, such as the last topic practiced by a user and the number of times each contact has been practiced.

The system, programmed before the age of Java, is showing its age and is in limbo as US WEST ponders Web-based training options. Bloom says the system has to compete with other training technologies for limited resources. "But we're not about to forget the potential for this technology," he says.

Bandwidth worries may evaporate in the face of new data delivery technologies, including digital subscriber lines (DSL), cable modem networks, and satellite transmission systems. Those technologies, which boast transmission rates far above standard 33.6-kilobyte transmission speeds over ordinary phone wires, are being rolled out to wider audiences in the United States. But both DSL and cable modem networks are susceptible to usage surges that degrade transmission speeds based on their shared data pathway architectures, analysts say. And cable modem and satellite systems suffer from lower "upstream" data speeds that hinder performance.

Companies that invest in their own intranets can dodge the bandwidth issue--at least as far as the firewalls that separate their networks from the public Internet--by using high-bandwidth fiber optic cable. But interoffice extranets that connect separate facilities run through the same data pathways as the Internet and are subject to the same electronic traffic jams.

For training providers, the immediate challenge lies in developing IBT that fits through today's constricted data pathways but still has the impact and immediacy of multimedia CBT. IDC's Julian, who surveyed large off-the-shelf IBT training providers and developers of IBT authoring products as part of her study, says that the survey participants are using creative strategies to provide interesting content with low data transmission volumes.

"If you try the demos of certain online learning providers, you find all manner of capability, so it all depends on what the customer is looking for," she says. "Real-time collaboration over the Internet is going to take a lot of bandwidth, but standard CBT with streaming audio is a different story."

Intelligent tutoring systems. It has long been the objective of many CBT developers to combine a CBT system's self-paced interactive learning environment with "intelligence" that tailors training to a learner's needs and allows voice-based interaction. And with significant recent advances in the areas of artificial intelligence (AI) and voice recognition technology, the goal of intelligent CBT--or intelligent tutoring systems (ITS), as it is known in research circles--is fast materializing, researchers say.

A handful of ITS systems that meet some of the seven attributes agreed to by leading researchers in the ITS arena as definitional characteristics are already in the field in both U.S. Department of Defense and private sector applications (see the box). Those systems, which include pilot systems for military technicians and broader ITS rollouts in telecommunications and other areas (see the sidebar, ITS in the Field: U S WEST), only hint at the extensive capabilities ITS promises.

"We're probably less than five years away from full-blown, robust ITS systems," says Beverly Woolf, research associate professor of computer science and director of the Center for Knowledge Communication at the University of Massachusetts. Woolf, who has focused on ITS and multimedia training for the past 15 years and has written 50 papers on ITS-related research, says technology hurdles including natural language recognition and AI implementation are falling faster than anyone had anticipated.

"ITS refers to advanced instructional software with certain features that set them apart from CBT, including generativity, mixed-initiative dialogue, interactivity, model-based instruction, and self-improvement," notes Woolf. "Our data suggests that, in general, the more robust an instructional system is with regard to those features, the more effective the system is instructionally."

Attributes of Intelligent Tutoring Systems

Generative. The capability to generate appropriate instructional interactions at run time, based on learners' performance.

Mixed-initiative. The capability to initiate interactions with a learner as well as to interpret and respond usefully to learner-initiated interactions. Natural language dialogue is sometimes a focus of this feature.

Interactive. The provision of appropriately contextualized, domain-relevant, and engaging learning activities.

Student modeling. The capability to assess the current state of a learner's knowledge and the implied capability to do something instructionally useful based on that assessment.

Expert modeling. The capability to model expert performance and the implied capability to do something instructionally useful based on the assessment.

Instructional modeling. The capability to make pedagogical inferences and decisions based on the changing state of the student model, based on the prescriptions of an expert model, or both.

Self-improving. The capability to monitor, evaluate, and improve its own teaching performance as a function of experience.

Source: Beverly Park Woolf, University of Massachusetts

Studies conducted by Woolf and researchers with the U.S. Defense Department show a marked improved in ITS over standard CBT, including baseline page-turner-type CBT applications and interactive multimedia. The studies, undertaken at the behest of Congress to validate continued research and development of ITS technology, compared simple ITS implementations with comparable CBT in military, adult education, and higher education environments. Some 400,000 subject hours of instruction went into the comparative analysis.

"Our studies show a 50 percent reduction in the amount of time to train to the same criteria" using ITS, says Wesley Regian, who heads ITS-related research with the U.S. Air Force Research Center. "If we hold training time constant, we saw a 34 percent increase in student performance over a given amount of training time. We were surprised ourselves at the gains made by ITS systems over conventional CBT."

Regian is credited with developing seminal prototype ITS systems for the Air Force, including a widely cited ITS that trains air traffic controllers at the Air Force's ATC training center in South Florida, and an ITS that features "Steve," a computer-based avatar who trains F-15 maintenance technicians.

The reason for the striking gains in impact by ITS is its ability to assess a learner's needs (student modeling), to present needed material accordingly (generativity), and respond to learner actions and questions (interactive and mixed initiative capabilities). While research in the cognitive sciences and instructional design and advances in programming languages have benefited ITS development, the technology has been awaiting improvements in voice recognition and natural language comprehension to achieve its full impact, researchers say. Recent advances in voice technology bode well for next-generation applications.

"It was ridiculously expensive and difficult to build these systems 10 years ago," says Regian. "Now, equipment cost problems have solved themselves, and we have third-generation authoring languages that make them easier to build and easier to change. And we've finally got workable voice technology."

Researchers discuss the collective capabilities of ITS in terms of a pedagogical agent that embodies the system's intelligence and interactive capabilities. In the case of the Air Force technician training ITS, the pedagogical agent takes the form of a virtual instructor. In other ITS applications, the agent does not take virtual form but is at work in the background assessing competency and choosing instructional material accordingly.

"Steve shows you how to do a procedure, then he critiques you as you perform it," Regian says. "He may decide to give you a remedial brush-up in a given task based on your performance, or go over certain areas where he thought you were a bit hesitant in responding. Then he tests your ability to perform the procedure." Learners are able to ask Steve questions from a pull-down menu, but voice recognition advances will soon improve interface capabilities.

Advanced systems will be able to field voiced questions using natural language recognition and artificial intelligence that parses speech for words pertaining to the subject. "These agents are very brittle and very narrow right now," Regian acknowledges. "If you asked Steve how to tie your shoes, he wouldn't have a clue."

Dexter Fletcher is senior research staffer at the Institute for Defense Analyses, a federally funded research and development center that provides research and policy analyses to the secretary of defense. Fletcher acknowledges that DOD has spent a significant portion of its training R&D budget on CBT and ITS technology dating back to the late 1960s. ITS has long been seen as crucial for the military, he says, because it spends some 6 percent of its annual defense budget on formal training courses. Fletcher explains that harnessing first CBT, then ITS is part of DOD's strategy to provide quality-validated training to a geographically dispersed audience on ever-tighter budgets.

Though earlier DOD development of ITS relied on proprietary hardware and software, much of the recent work has been conducted using standard PCs, commercial authoring packages, and private-sector voice technology. ITS technology and other DOD research are wending their way from DOD's R&D labs to the private sector--and vice versa--through academic and private-sector channels. "The magnitude of that back-and-forth flow is more than many people realize," Fletcher notes.

Fletcher, who has been researching ITS and other training technologies for more than 20 years, agrees that ITS will achieve its full potential in the next decade. "Natural language has been the sticking point, but we're seeingmajor progress in that area--and solving that area will solve lots of other problems. We need something pretty close to 100 percent speech recognition, and suddenly today we have off-the-shelf systems that achieve 90 percent or better recognition." The rate at which the recognition gap has been closing in just the past three years has been remarkable, he adds.

"We tend to use old metaphors in describing new technologies–for example, the horseless carriage and the wireless," says Fletcher. "I think when we talk about intelligent tutoring, we're using a metaphor that we'll eventually see is equally primitive. That's why I want to be alive 20 years from now."

Motorola's Learning Objects Initiative

Motorola University, Motorola's training arm, has embarked on an ambitious development effort to create an object-based learning library for its worldwide training programs. The program, launched in mid 1996, is among the first to attempt to put object-based learning into practice on a global scale.

"It's a four-tiered approach," says Christine Good, director of learning technologies for the Schaumburg, Illinois-headquartered Motorola U. "First comes the network infrastructure on which to build the system, and we now have 20 servers worldwide through which to distribute the training."

The next two components --an object-oriented database that will store a library of learning objects for everything from technical training courses to management education and a design template to create online learning using objects stored in the database-- are currently under development, says Good. Testing of those components will likely begin later this year. The final tier, including refinement of an end-user interface and development of a user profiler that will aid in matching content with a learner's needs, is slated to get underway next year.

The system, based on an object-oriented database with a proprietary Java-based authoring tool called Wizard, differs from more long-range learning object approaches such as DOD's ADL initiative in certain key respects. At least in its initial phase, the system is geared to allow Motorola's training developers to piece together CBT content that has been broken down into objects rather than use an automated approach to sifting objects to build a CBT. Training developers are currently learning a methodology for taking existing content and breaking it into reusable objects that are "meta-tagged" with attributes that include not only the content, but also additional tags that define the object's interactivity, the competencies it relates to, and other information.

"What's going to be the key as we move forward will be learning how to use that indexing and meta-tagging information in a manner that doesn't become overly convoluted," says Good. Later generations will rely on the user profiler to automate object selection and allow customized learning tailored for a learner's needs, she adds.

Why wade into an emerging technology that, like any system in today's fast-changing digital realm, entails risks of obsolescence and no guarantee of success? "We're a global organization, and we need to distribute training far and wide," explains Good. "Instead of having every facility create its own training CBT, we need to reduce and standardize what we already have and be able to provide quality and consistency. We believe this approach will allow us to do that."

Source: Motorola University

Learning objects. In what some training software developers describe as the Holy Grail of computer-based training, technology pioneers envision a future in which learning content takes the form of independent, reusable software objects. These bite-sized components of learning, called learning objects, could be used in combination with one another to provide any and all manner of CBT (also IBT and ITS), customized to a learner's needs and then rearranged for another training purpose.

By making learning content granular by converting it into learning objects, training providers can quickly compile CBT for various training initiatives, then reuse the objects for widely different training needs without the need to program from scratch. More precisely, a reservoir of learning

objects contained in a knowledge database can spring into action based on defined learning objectives and instructional design parameters.

The shift to object-based learning content, still nascent, represents the final segment of the transition from custom training delivery to mass customization of training, proponents say. The concept, dependent on new and emerging capabilities in software programming, database applications, and instructional design, would be as radical a shift in training delivery as the difference between classroom instruction and CBT.

"It has a huge potential impact, when you consider the ramifications of being able to present any content in a common format," says Phillip Dodds, a multimedia expert who provides consulting services to the federal government on learning objects and other technologies. With true object-based learning, "the construction of learning libraries becomes feasible, and you can really begin to build an economy around learning objects that can be used to build and repurpose training," he says.

Database systems developer Oracle Corporation recently partnered with multimedia CBT provider Macromedia to forge inroads in object-based learning through its recently formed Oracle Learning Architecture Group. Motorola University, which provides training worldwide to Motorola's manufacturing facilities and other locations, is pursuing its own strategy toward learning objects (see the sidebar on page 69). And the White House Office of Science and Technology Policy, together with the U.S. Department of Defense, is striving to coordinate research and development of object-based learning through its Advanced Distributed Learning initiative, a public-private research consortium.

The highly technical issues surrounding efforts to develop object-based approaches to learning are further confused by a lack of definitions or standards on what constitutes a learning object. Interpretations of learning object systems represent a spectrum of capabilities that range from simple rules-based systems that break CBT content into reusable chunks to a long-range purist definition that further granularizes content and relies on software to sift an object library in building CBT.

"The acid test for true object-oriented content is whether or not the system calls for use of an object-request broker--essentially a computer server that uses standardized protocols that identify and deliver objects based on a defined training need," says Dodds of differing approaches to learning objects. The federal government's ADL initiative is evidence of the long-range approach. Object-based systems already in use are incremental steps in that direction, says Dodds.

The ADL initiative, launched in November 1997, seeks synergy from the Defense Department's need to lower training costs and the private sector's growing interest in object-based learning. "ADL will ensure that a common set of guidelines for this new object-oriented learning environment is developed through active collaboration with the private sector," says Don Johnson, a deputy director of defense training in the office of the secretary of defense. The training software industry's involvement is critical, says Johnson, "because they'll be putting these guidelines into practice in developing object-oriented learning." The consortium has issued initial guidelines for a common ADL framework and plans to begin testing software tools for writing learning objects in the fall of 1998.

Meanwhile, training and performance experts are mapping out a new paradigm for learning based on the concept of reusable learning objects. M. David Merrill, a professor at Utah State University's Instructional Technology Department and director of the ID2 Research Group, an instructional design development organization, has outlined a strategy for parsing learning content into object form (CBT *Solutions*, March/April 1998). The methodology for deconstructing

content into consistent object components will become critical as training professionals begin employing object-based training approaches, writes Merrill.

Gloria Gery, a pioneer in conceptualizing electronic performance support methodologies and, more recently, learning objects, speaks of radical shifts needed in how trainers view their roles to accommodate the shift to knowledge conservation of the sort embodied by learning objects. She says, "Training professionals are creators of knowledge through their methods of knowledge acquisition and representation. To date, the use of the content has been through training courses. That must change."

In the brave emerging world of learning objects, knowledge must be stored or accessible independent of its use, explains Gery. "Trainers must be involved in the connection part of things, in linking things into meaningful contexts, or working with developers of search engines to define requirements for locating and linking knowledge. Business and training folks increasingly understand that the capture, storage, connection and reuse of knowledge in all forms will become a strategic and competitive advantage."

"But," says Gery, "it hasn't been operationalized very well yet." That will change as the learning object approach passes from R&D through pilot implementations and into a mature technology, she adds.

Experts generally agree that though learning objects represent a major change in CBT development and delivery, the technology's full promise is more than a couple of years away.

Says Gery, "The cycles for reconceptualizing things like developing and programming software and designing and developing instructional programs always take longer than we either expect, would like them to, or need them to. To be honest, I don't expect a critical mass to occur for a while."

Voice Recognition in a Wearable EPSS?

A consortium of manufacturers, research institutions, and the U.S. Army's training arm have developed a wearable EPSS system that uses voice recognition to allow technicians hands-free access to technical material while on the job.

The system, a bold combination of miniaturized computer hardware, performance support software, and a voice-activated interface, was developed through a $1.2 million contract from the U.S. Army's Tank Automotive Research Development Engineering Center (TARDEC) and the Defense Advanced Research Projects Agency (DARPA). The system is based on hardware developed by Interactive Solutions, a subsidiary of telecommunications electronics maker Teltronics.

The system is currently being tested by the U.S. Army for use in equipment maintenance, diagnostics, and repair at Army National Guard bases under the name SmartDart.

"If you're working on a diagnostic or repair job, and your hands are getting greasy, and you're trying to access a laptop-based EPSS, it's easy to see that's not a convenient way to access material," says Gary Bosworth, program manager for SmartDart with consortium member Raytheon Systems Co. "This system provides electronic performance support in a manner useful to technicians as they do their jobs."

A voice command-based EPSS, SmartDart displays technical material or instructions on a tiny, head-mounted LCD screen or a small flat-panel display. A heads-up display (like

those used in fighter jets and a few luxury car models) that projects video images onto eyeglasses worn by a user is in the works, says Bosworth. A VR-based navigation system lets users navigate through technical documentation and diagnostic and repair instructions as needed via voice commands. Users can query the system on voice command options at any time to help navigate to material they need.

The performance support methodology at the heart of the system comes from consortium member General Motors, which has been working for years to provide a performance support tool easy for technicians to access. The private-sector version of the system, called Mentis, is being tested by service technicians at several GM dealerships.

"The days of a technician pulling up his tool box to the car and using only the knowledge in his head to accomplish his task are over," says John F. Smith, general manager of GM's Cadillac division, regarding GM's decision to support development of the technology. "There's too much to memorize and the level of expertise required exceeds traditional training." If the system meets expectations, GM plans a rollout to its more than 8,000 dealerships worldwide.

Voice recognition. If the recent onslaught of media coverage can be believed, voice recognition (VR) technology finally appears ready for mainstream applications. The question now facing the IT community is whether people are ready and willing to unplug their keyboards and talk to their computers.

New desktop PC-based systems that run on the latest generation Pentium chips and incorporate arduously developed VR algorithms have generated a wave of enthusiasm in the media for their recognition accuracy rates of 95 percent or better. The new generation of VR systems also allow more natural speech rather than the word-pause-word requirements of earlier systems, and do so with a vastly shortened training regimen to adapt the system to an individual user's speech style. Vendors claim their products can be installed and operational in less than an hour.

Three such systems, from IBM, Dragon Systems, and Lernout & Hauspie Speech Products, are said by VR experts to have achieved a price-performance ratio that makes them attractive to corporate audiences. The newest version of IBM's much-publicized system, ViaVoice, has a vocabulary capability of 128,000 words, including room for 64,000 user-added words to tailor the application to a particular need. The upgraded system, released in June 1998, also features some natural language capabilities--the ability to understand and act on statements and commands by inferring their meaning through artificial intelligence.

"This technology has migrated from a science project to a business solution," said Bruce Dougherty, vice president of sales for Nuance Communications, in a January 1998 article trumpeting VR in *Information Week*. "We've seen a real change in the way people are treating it in the last six months," he added.

The *Information Week* article also cites growth projections from consultancy Voice Information Associates that predict an increase in VR-related sales from $245 million in 1997 to $335 million in 1998--and surging to $810 million by 2001. The technology is growing fastest in telecommunications environments, including call centers harnessing VR to route calls or answer basic information automatically.

Training and performance support applications that use VR to free learners from using a keyboard have been a development priority for training technology developers in the industrial and military technical training arenas. VR is considered an adjunct or enabling technology to

portable EPSS and ITS systems and until recently hampered initiatives in those areas with unacceptably low recognition accuracy rates. "We've been to hell and back on voice technology," says one developer of ITS technology that makes use of VR.

New VR capabilities are breathing life into applications, including a Defense Department ITS development initiative and a wearable EPSS developed through a public-private consortium (see the box on page 70).

The technology promises new techniques in language tutoring. One such tutoring system under development at Raytheon Systems Company combines voice recognition and synthesized speech capabilities to tutor students in a foreign language. The PC-based system, Rave, is aimed at multinational companies that need to bring workers up to speed quickly on new languages. Developed using ISD principles that emphasize frequent student interaction, the system is currently in the testing phase.

Still unclear, however, is the extent to which new-generation VR is or will be adopted in the CBT arena, either as a tool to be harnessed by multimedia authoring applications or as a feature in off-the-shelf CBT. The largest provider of off-the-shelf multimedia CBT, Dublin, Ireland-based CBT Group PLC, says it has no current plans to incorporate VR into its line of CBT products. But a company-sponsored user conference in late spring found growing interest in audio capabilities, says CBT spokesperson Cindy McCaffrey.

Asymetrix Learning Systems, a dominant maker of multimedia authoring tools for CBT, says the newest version of those products will include plug-in support for VR that will allow its applications to incorporate VR engines used in IBM and other vendor VR products. But Asymetrix marketing director Raine Bergstrom says the company hasn't yet felt an uptick in demand for VR capabilities in its applications.

"Everyone seems to think its a great idea, but as far as I can tell, no one seems to be rolling out voice applications for CBT," says Bergstrom, adding that he was impressed with the IBM technology at a recent product demonstration he attended. "I think it's a technology that's ready for people to start experimenting with, and everyone thinks that eventually you'll be talking to your computer and it'll be talking back, but I'm sure there'll be many iterations along the way."

Implications of the Digital Revolution

The Internet, intelligent tutoring systems, learning objects, and voice recognition--all part and parcel of the ongoing digital revolution. Both together and separately they are forever changing work and learning. Old jobs are disappearing quickly. New jobs are appearing even more quickly. Retraining has never been more important to the well being of organizations and the people in them. At the same time, the rapid pace of change makes it more difficult than ever to find the time for learning new skills to replace those that are becoming obsolete at an ever-increasing rate.

The digital revolution, which has caused the skills gap, is also providing the tools to solve it. The emerging learning technologies that are described here will further blur the lines between work and learning. Increasingly the two will occur together. But they will happen best--and most profitably--in organizations that are conscious and focused on making this happen.

This will require much of practitioners of workplace learning. They too must retool themselves to capitalize on the opportunities and avoid the pitfalls inherent in the unfolding revolution at work. Although classroom training will remain a necessary vehicle for creating learning, it will increasingly be augmented with, and in some cases replaced by, electronic means of learning. This suggests that the best strategy to pursue is to embrace rather than resist this evolution and to develop the technology literacy and skills required by it.

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