

Improving equipment reliability through e-learning It will change the way people work, learn, communicate and solve problems

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E-learning addresses the challenges process companies will face in the near future. It will change working and learning and dramatically improve equipment reliability throughout the process industries. Several technical, financial and cultural commitments are required to successfully implement e-learning.

"In times of change, it is learners who will inherit the organization. And those who refuse to learn will find themselves well-equipped for an organization that no longer exists." (Kenneth T. Derr, Chairman and CEO, Chevron)

The process industries will migrate to daily Internet use to rapidly build the knowledge and expertise of personnel and to greatly expand communication of data and information. The Internet will provide companies the tools required to build true "learning organizations."

While process companies are confronted with increasing economic and regulatory demands, the Internet offers incredible opportunities. To remain profitable, process companies must operate their facilities in a manner that is continuously reliable, safe and environmentally responsible. This requires experienced and knowledgeable personnel who have access to information and an organization that is receptive to and capable of change. Meanwhile, a generation of experienced workers is nearing retirement and younger workers are more difficult than ever to attract and retain. This loss of experience threatens to deplete companies of the skills required to compete and remain successful.

"Every \$1 spent on training delivers \$30 in productivity gains within three years." (Motorola)

This collision of business needs with a communications revolution presents the opportunity to permanently improve an organization's efficiency. Network technology is enabling companies to meet challenges, change faster, learn faster and become more productive.

E-learning is a fundamental shift in training and working, transcending early efforts of knowledge management and CD ROM or video training. It delivers learning to employees through the network, on demand, when there is a real need for information, knowledge, expertise or assistance. Groups of employees will leverage their collective knowledge for individual use, transfer information, solve real problems, as well as document and archive the solutions. This group interaction will build a learning organization that increases employee expertise and distributes standard and consistent information.

"Fifty percent of training will be technology-based (i.e., online) by 2002." (Gartner Group)

Increased pressure. Increased financial and regulatory pressures have driven equipment reliability to a top priority. Production losses, excessive maintenance costs, safety incidents, environmental impacts and fines, and inefficient operation are the unacceptable consequences of poor reliability. World-class reliability requires a knowledgeable workforce, capable of solving problems and maximizing plant production. Soon, it will be increasingly difficult to find, attract and retain the workforce required.

Reliability is a difficult objective. Industrial equipment systems are specialized and complex. Equipment professionals must have knowledge of multiple disciplines (mechanical, electrical, civil, chemical, etc.) and an understanding of plant operation, as well as competence in communication and economics. There is no college degree in industrial equipment reliability. Additionally, personnel must be able to select and disseminate information relevant to the particular scenario. Often, over 50 years of relevant information exists that pertains to a particular component (e.g., an oil rig).

Plant engineering is a team effort of engineers and engineering technicians. The primary function of this group is to provide the mechanical technical guidance necessary to head off potential production problems or to help solve problems that do develop. Plant engineering personnel need a broad background in plant design, corrosion prevention methods, mechanical failure analysis, work methods and startup problems. A knowledge of bearings, seals, lubrication, material failure mechanisms and machinery analysis is required. The minimum knowledge required in these diverse fields is the amount necessary to recognize situations that require consultants in lubrication, industrial engineering and other specialties to expedite the solution of major problems.¹

Equipment reliability must be built into eight critical functions: design, manufacture, selection, installation, operation, maintenance, monitoring and repair. However, these functions require knowledge of multiple disciplines, understanding of how the system is interacting with the process and familiarity with hundreds of system components. Equipment reliability requires understanding not only the equipment itself, but also the complexities of the system in which it is installed.

Knowledge workers everywhere. *Information and knowledge are the thermonuclear weapons of our time. Knowledge is more valuable than natural resources, big factories or fat bankrolls.²*

Building knowledge and understanding into front-line operations and maintenance personnel results in huge gains in process plant reliability. A refinery in Anacortes, Washington, has recognized the critical role of people in equipment reliability. Building knowledge and problem-solving skill in their operators resulted in an increase in mean-time-between-repair (MTBR) from four years to over seven years for pumps. In addition, the average life of general-purpose turbines is 15 years between overhauls and 10 years between overhauls for compressors. Employee knowledge, combined with management and engineering support were cited as key elements in these dramatic improvements. Operators learned to recognize when pump performance is less than optimal and take steps to prevent failures.³

How did employees learn in the past? Employees in the past built outstanding knowledge of mechanical equipment by solving and attempting to solve problems. Plant personnel repaired equipment with limited outside resources by discussing problems with each other and collaborating to find solutions. To keep the plant running, they modified and made changes to equipment. Sometimes the modifications worked, and other times they resulted in failure. In today's operating environment, exposure to failure is unacceptable. Lessons of the past resulted in creating standards, procedures and additional documentation.

Consequently, there is now an extreme focus on written procedures and electronic systems that attempt to force people into proper action. There is even hope that "expert systems" – systems that identify cause of a problem given the set of data surrounding the problem – will successfully diagnose equipment problems. The ever-expanding focus on data, procedures and documentation, coupled with reductions in training budgets, has crippled the past's learning, and reduced problem-solving expertise in the workforce.

Technologists claim we will solve all of our problems if we just have better data, faster connections and more computing power.⁴

Unfortunately, databases, expert systems and procedure manuals do not solve equipment problems – people do. Human skill cannot be replaced. Databases and expert systems do not notice an odd noise,

flakes of coupling shim on the ground or a gauge reading that isn't the same as the day before. Before monitoring systems, databases and expert systems, people with knowledge, understanding, skill, expertise and wisdom solved equipment problems. They solved problems because they understood the systems they were working with. Technology has provided excellent benefits, but it cannot replace the knowledge and expertise of skilled professionals.

People do (Chevron)

Companies that thrive in the new economy will recognize people as their greatest asset and create a staff of knowledge workers. These workers will take reliability to the next level by having immediate access to information and resources without having to attend the school of hard knocks for 30 years. Operators will recognize off-design performance and intervene to prevent failures. Maintenance personnel will repair every piece of equipment properly every time. Engineers will understand the equipment fundamentals as well as the interaction of the process system into which the equipment is installed.

Loss of talent. In coming years, improving equipment reliability will become an even greater challenge due to the reduced experience level of process plant personnel. The Bureau of Labor Statistics says that the workforce growth has slowed to 1.1% per year, which will continue until 2006. Meanwhile, experienced plant personnel are leaving in record numbers. *Maintenance Technology* magazine recently conducted a salary survey. Of maintenance professionals responding, 60% were over 45 and only 3% were under 30 years old.

The workers who have contributed the most toward plant reliability improvements are retiring. At a minimum, the retiring experts will walk out of the plant knowing critical facts about specific pieces of equipment. However, the greatest loss to companies will be the vast store of knowledge, expertise and problem-solving skill, which will disappear with those individuals. Furthermore, many of the best professional equipment reliability trainers are nearing retirement. Who will replace them?

While the current generation of workers is nearing the end of their careers, younger workers are looking for opportunities to develop, build valued skills, achieve certifications and add to their store of intellectual capital. These new workers are more concerned with maintaining marketable skills than job security, pension plans or corporate brand name. These workers change jobs more frequently, and stay at each job for shorter periods. Lifelong careers and corporate loyalty are being replaced by "career security" achieved through continuously learning modern skills. Yet, pressures on process companies have cut training and travel budgets to the bone, limiting worker growth opportunities.

What are the opportunities moving forward? To take advantage of the opportunities for improvement in business and organizational efficiency, process companies need to change the way employees learn. Companies must recognize that their ability to rapidly develop knowledgeable plant personnel will provide a great competitive advantage. It is the front-line workers' ability to solve problems, prevent failures and properly operate, monitor, maintain and repair complex systems that will deliver extraordinary gains in equipment reliability, production, profitability, environmental performance and safety. The question for corporations is how do they build the knowledge and expertise required of every employee in the organization?

Are you ready? ". . . *e-Learning is going to be so big, it will make e-mail look like a rounding error.*" (John Chambers, CEO, Cisco Systems)

Future companies will need to provide the ability to build skills, knowledge and experience more rapidly as workers change jobs more frequently and stay at each job for shorter periods. E-learning will provide a revolutionary new means of delivering education to an entire organization. It is a combination of technologies that provides a comprehensive learning solution to improve industrial equipment knowledge and reliability.

Definition of e-learning. *"E-learning operates in real time, delivering what you need, when you need it."*
 (Greg Priest, Smartforce)

E-learning is a transformation of learning and working. E-learning is much more than a talking head regurgitating traditional training courses broadcast over a network. E-learning is a convergence of training, knowledge management, collaboration, mentoring, publishing and customer support. Learning will be integrated into the daily lives of workers so that information and knowledge required for a specific job is available on demand. Collaboration, online mentors and personalized learning will augment and sometimes replace traditional classroom training.

The focus of e-learning is performance, becoming competent in the least amount of time, with the least amount of training – not the most. E-learning is a broad set of applications, which can be customized to meet needs of individuals based on current knowledge, learning style, job requirements, career goals and personal preferences.

Lifetime learning. E-learning converts education into a lifelong event, where the employee learns when and where there is need for knowledge or information. The equipment specialist can learn about equipment systems the first day on the job, practice equipment failure scenarios every week, take a 15-minute course on a specialty piece of equipment when there is a question, help an employee in another plant solve a problem by sharing knowledge and experiences, attend a symposium lecture of interest without leaving the plant and review important points at a later date.

Traditional view vs. e-learning. To understand e-learning, compare it with traditional corporate training (Table 1). Traditional training has been viewed as a singular event requiring employees to take in massive amounts of information, then at some distant point in the future, apply a piece of that information to solve problems. E-learning replaces this view with continuous learning for the purpose of solving problems.

Table 1. Traditional vs. e-learning	
Traditional corporate learning	E-learning
New employees spend weeks or months on the job until the next scheduled training seminar.	New employees begin learning on day one.
Equipment specialists spend years building a personal library of technical resources before they can effectively solve problems.	A complete technical library is available to everyone in the plant from day one.
Existing employees attend one or two classroom sessions per year, trying to absorb hours of information in one sitting.	Better retention. Personnel learn in 5-15 minute modules whenever there is a need for information.
Memorized and bound material is the only information available to the employee after the classroom training is over.	Up-to-date learning materials are available 24 hours a day, 365 days a year.
Knowledge and information are held in the heads of a few onsite "experts."	Knowledge and information are available on demand to everyone in the organization.
Trainers decide which information is needed by the employees.	Employees decide which information they need to solve problems at hand.
Training is not tied to solutions to problems.	E-learning is a normal means of reaching solutions and the solutions are

documented.

"The most important factor is not the distance between learner and instructor; rather, it is the distance between learning and action." (Estee Solomon Gray, Chief Learning Officer, Interwise)

Many forms of e-learning. E-learning is a framework that includes training, but also provides many other forms of learning that may be applied to best meet the particular situation. Advantages and disadvantages of learning methods are listed in the appendix. The table is followed by a description of how each method can be used to effectively improve process equipment knowledge and plant reliability. But, the best way to illustrate e-learning is to provide an example of how it will be applied in a process plant environment.

E-learning at work. A plant operator is making her rounds, checking oil levels on the pumps in the unit for the 900th time. She is not really sure why she checks them, she is just supposed to, so she does. When she gets back to the control room, she decides to take a 10-min. minicourse on oil lubrication. The control room has access to an e-learning Website, and she enters her security code. In less time than a coffee break, she is exposed to exactly the right amount of information she needs as an operator.

She quickly understands the function of lubricating oil, why oil is critical, and that oil is part of the lubricating system. She knows how that system works and that oil is the lifeblood of the bearings. She also learns that oil condition reveals a myriad of information related to reliability and/or pump failure. On her next series of rounds, she sees water at the low point of the oil reservoir, something she remembered in the "What to look for" section of her minicourse. She brings it to the attention of a maintenance worker in the area and another potential for downtime has been averted. Her supervisor gives her a brief moment of praise, and she decides to learn more about different systems in other minicourses. As a subscriber, her knowledge profile is always on record so she can always be presented with information suited to her developing experience base.

Meanwhile, in another part of the plant, the maintenance technician she notified goes back to the shop and accesses a chronological discussion thread concerning the pump with water in the oil. He realizes that this is the third time this situation has developed in the past 18 months. So he decides to take a quick review of the causes and failure mechanisms for this type of situation.

His minicourse or problem search reminds him that packing adjustment and latent steam are two causes for water in the oil that fit this particular situation. He learns that a sample of the water in the oil can be sent to the lab and analyzed, which will help him determine the origin. The water turns out to be steam condensate, and appropriate maintenance corrections are made. Through e-learning, the maintenance worker did not just get data, records or abstract knowledge better suited for an engineer or operator. He received enough maintenance-focused knowledge to make an insightful decision and make an incremental improvement in the plant's reliability. And he got the information just-in-time.

Because this was the third time this particular pump had water in the oil and because this was a common problem in this operating unit, he notified the reliability, maintenance and operations supervisors, pointing out oil mist systems as one of the "industry best practices." The new aggressive maintenance manager with a reduced budget said, "We can't continue spending maintenance money on preventable poor reliability, the buck stops here."

Using e-learning, the three supervisors gained access and references to current industry trends and best practices (not merely the way they've always done it). They looked into oil-mist systems and found that the mean-time-between-failure of the pumps in the operating unit could be increased dramatically and that the implementation cost would "pay-out" in one year. This made the operations manager very happy because this meant less downtime or more continuous, predictable and reliable production. The maintenance manager was also very enthused, as this would help him meet his budget requirements. As

for the reliability department, they got their dream project. Why this successful outcome? Because people learned. They now understand their value, what they're doing, why they're doing it and, most importantly, what they can do to improve. Ultimately, the organization increased its efficiency in learning and benefited every step of the way.

E-LEARNING BENEFITS

Learning is driven by business needs. Since much of the power to make real-time decisions resides among front-line personnel, successful future companies will provide these workers with the information and knowledge to make decisions that yield a positive business impact. Picture all of the equipment books ever written and all of the OEM training manuals available at will or in small interactive chunks, searchable from the desktop. When the operator needs to figure out why an oil ring isn't spinning, she can learn about oil ring lubrication in a 10-min. exercise. Business situations create the questions, e-learning provides the solutions.

Employees can take charge of their own career goals. The evolving employee pool of the future wants control over career development. Individuals can acquire the skills they need to remain competitive and marketable in a continuously changing work environment. As new technologies are introduced requiring new skills, e-learning enables employees to quickly gain up-to-date skills. In effect, e-learning can allow workers to manage their own lifelong learning. The company creates a knowledgeable workforce, and employees are empowered to build the skills they desire.

Anytime/anywhere. E-learning brings learning to the desktop, in most cases eliminating travel costs and classrooms. Learning can take place whenever a need arises. Learning studies show knowledge retention to be higher when learning is based on a need. With this type of learning, companies are not required to schedule a manufacturer's representative to provide instruction, nor do they have to send personnel offsite. If there is a need in the middle of the night, answers are available.

Consistent content. E-learning delivers world-class, consistent training material and communicates a consistent message across the organization. The content viewed by all employees can be the finest thinking from world leaders in equipment reliability, the most experienced company specialists and the most skilled workers. Companies can spread experience across plants and beyond international boundaries with quality learning, collaboration and information available to all employees.

Customized to learners' needs. E-learning delivers customized learning environments for employees with different experience levels, learning styles, career goals and information needs. Even if the content is standardized, e-learning configures the learning style to meet users' needs. Before beginning, users build a profile by completing skills and learning style assessments. This eliminates material the learner already knows and delivers material at the appropriate learning level. In terms of style, some people prefer text over video, passivity over interaction or scenarios over testing. User profiles create a learning environment based on individual learning preferences. Customization improves employee information retention and reduces learning time.

Does e-learning work? E-learning works. Students attending an online network academy perform better than students in the physical classroom. E-learning enables people to engage in many activities more efficiently, and when real discovery occurs, it is documented. Online classrooms take the place of physical classrooms, threaded discussions replace voice mail messages, email replaces notes in the company mail, online mentors augment apprenticeship programs, and online help desks are substituted for technical support numbers. International Data Corporation has released preliminary results of the first extensive e-learning study. It finds that 100% of managers in various industries who have used e-learning would recommend it, and 60% would strongly recommend it.

Who uses e-learning? Several companies have used forms of e-learning for years; others have integrated e-learning into a normal part of business. More industries are quickly adopting e-learning. It is

now possible to get an MBA online with Duke University, and several other universities are complementing their traditional programs with e-learning. Information technology (IT) professionals regularly attain certifications through online schools. The investment newspaper, *Investors Business Daily*, provides e-learning on investments as a free service for subscribers. The New York Times Internet site even provides e-learning for simple cooking tasks such as "how to carve a chicken."

In the process industries, e-learning is beginning to enter the scene. The Masie Center, a research center focused on how people learn, estimates that 92% of large corporations are implementing some form of online learning this year. In the process industries, companies are beginning to build online corporate universities focused on corporate policy and safety standards. Some Internet companies sell traditional training services for the process industries through their Websites. E-learning dedicated to improving equipment reliability is not yet available.

Implementation requirements. Implementing e-learning requires technical, financial and cultural commitments. Requirements include technology, infrastructure and content. Building the system with these elements requires significant investment, which is easily offset by enormous cost savings. To maximize return on investment, companies need to make a cultural commitment to the e-learning system, and involve the correct personnel in the decision-making process.

Technology, content, learning environment. Technology required to deliver e-learning is a combination of hardware and software. Personal computers with Internet access are already available in most locations. For some media-rich content, such as streaming video, broadband access (greater than 250 kb/sec) is required. Delivery should be through dedicated servers with adequate capacity for the intended number of simultaneous users and also should allow scalable usage to meet corporate needs. Finally, e-learning content must be backed up with an e-learning management system – software designed to track learning activity, user skill profiles and learning preferences.

Content must be world-class from true industry experts to be engaging for the user and achieve maximum value for the corporation. Content must be designed for e-learning applications and developed with open Internet standards, such as HTML and XML languages. E-learning content should be divided into easily searchable modules, so the user can quickly find material relevant to the task at hand. Furthermore, content should be in a format that is challenging, interesting, engaging and easy to use. Videos of classroom training in a digital format will not suffice. Users will not enjoy a computer screen with a talking head.

Finally, the company will need to ensure that an appropriate learning environment is available. Employees need a place to learn where distractions can be minimized. Some companies have set up dedicated learning offices. Learning requires concentration and a minimum level of privacy.

E-learning financials. E-learning delivers much more than traditional training programs. Costs associated with training can be greatly reduced. However, the greatest savings lie in creating a more productive workforce – a workforce of problem solvers. Comparing e-learning to the cost of traditional corporate training methods shows significant cost reductions (Table 2).

Table 2. Cost of learning delivery methods	
Delivery method	Average cost per student*
Instructor-led training (5 two-day courses)	\$1,680
Online/Internet/Web-based training courses	\$800
Enterprise server software + 5 custom-developed courses	\$600

Learning network subscription (1-yr subscription)	\$500
CD ROM-based training (site license for 5 courses)	\$500
Interactive satellite broadcast (5 half-day sessions)	\$250
Video training (5 one-hour video tapes)	\$150
1-way satellite broadcast (5 two-hour courses)	\$75
*Based on the total cost to deliver 5 courses to 1,000 employees	

Cost savings are more dramatic when one includes costs associated with classroom training, such as travel costs and time out of the plant (Table 3).

Table 3. Comparison of classroom training to e-learning		
Expense	Classroom: instructor-led training	Network delivered learning
Airfare (15 students at \$1,000)	\$15,000	\$0
Meals and hotel (15 students for 5 days @ \$200 per day)	\$15,000	\$0
Taxi/shuttle (15 students at \$40)	\$600	\$0
Travel time (15 students at 10 hr @ \$50/hr)	\$7,500	
Time in training (15 students for 40 hr @ \$50/hr)	\$30,000	\$30,000
Classroom (\$500/week)	\$500	\$0
Full-time instructor (\$1,500/day for 5 days)	\$7,500	\$0
Part-time mentor (1 hour/day content for 5 days @ \$150 per hour)	\$0	\$750
Books (15 students @ \$20)	\$300	\$0
Network bandwidth (15 students for 40 hr @ \$6/hr)		\$3,600
PC rental depreciation (15 students for 1 week @ \$40)	\$0	\$600
Total cost	\$76,400	\$34,950
Savings per class meeting		\$41,450
* Network distance learning: A training evolution and revolution, Cisco Systems.		

In addition to the savings outlined, there are additional benefits for human resource (HR) departments because the e-learning management system updates and maintains training records. The e-learning management system will help HR create a learning profile of the entire plant, automatically notifying employees to ensure that they receive required training at the necessary intervals.

Cultural requirements. Companies that achieve the greatest benefit from e-learning will actively pursue an e-learning strategy. Companies cannot passively wait for employees to find e-learning content on the Internet and train themselves. They must provide the cultural support for employees to learn and involve the appropriate departments in the decision-making process.

Management must support the initiative from top executives to front-line managers. Executives must promote, support and evangelize the learning organization. Front-line supervisors will need to understand the initiative and provide support for employees who are learning, searching the Internet and collaborating online. IT and HR departments will need administrative training to manage the e-learning network. IT will

need to be involved in the technical implementation, ensuring systems compatibility and bandwidth availability. HR will need to utilize the tracking and administrative systems built into e-learning. Finally, employee feedback must be used to continuously improve the e-learning network content, delivery and management.

"Over 70 million people are receiving an education on the Internet this year. One day, training for every job on Earth will be available on the Internet. Are you ready?"⁵ HP

Appendix: Learning delivery methods			
Delivery method	Description	Advantage	Disadvantage
Classroom, instructor-led training (ILT)	Instructors and learners in the same place at the same time.	Good for interactions between instructors and student, and students with physical objects. It is the most enjoyable way for some people to learn.	Expensive, requires large blocks of time, often requires travel, and delivers the same course to all students without regard for each student's skill level.
Virtual class	Instructors and learners in different places at the same time, using a shared video application, with two-way audio.	Eliminates travel and classroom associated with ILT, increasing convenience and cost savings.	The number of students is limited, quality of the experience is diminished when it is not live and in person.
Virtual lecture	Instructors and learners in different places (possibly at different times if the lecture is recorded), students may be able to ask questions through e-mail.	Consistent content delivered to an unlimited audience size, providing convenience and cost savings.	Very limited interaction between instructors and students.
Self-paced	Anytime, anywhere, learner-controlled training. Student interacts with multimedia presentations and seeks the information needed at the present moment.	Convenient, cost-efficient, and very effective when the multimedia learning is well designed. Consistent content can be delivered to an unlimited number of students with varying skill levels. Can be a work-aid, providing student with assistance on demand.	Development costs are considerable, and requires motivation and participation from students and management.
Mentoring	One-on-one assistance and coaching through e-	Personalized response to needs, direct source of expert advice. Nothing	Personalized mentoring can be expensive.

	mail, phone, Web application or in person.	beats an excellent mentor.	unavailable in some locations and is only as good as the mentor.
Discussion board, threaded discussion	Asynchronous text discussions on any topic, users ask questions and respond over the Internet.	Discussions are documented, capturing employee thoughts and ideas. Answering and asking questions are excellent aids to learning.	Requires monitoring to maintain productive discussions and prune off-target postings. Can also provide poor-quality information.
Simulation	Student interacts with scenarios, which allow him or her to practice job skills at the desktop.	Reinforces learning by allowing the student to practice job skills. Rapidly builds employee skills in a safe environment.	Expensive.
Chat	Online, real-time conversation.	Very inexpensive.	Usually unproductive, cannot be captured or documented. Users need to be able to type.
Real-time discussion	Can be led by an expert. Unlike chat, it can be archived.	Simple to implement. Productive discussions can be saved.	Only as good as the expert leading the discussion.
Study group	Students working together to help each other learn, students can be using any media.	Students can assist and motivate each other, inexpensive, delivers prepared content to a larger number of users.	Not monitored, difficult to track or document completion of learning.
Help desk	On-demand assistance, can be e-mail, message board or phone.	Easy to implement. Assistance from an expert can provide real value.	Cost required to provide the expert.
E-mail	Communication through e-mail via formal mailing list or personal contact.	Everyone has e-mail. Users can send messages to colleagues to collaborate and share information.	The person in need has to know where to send the message. The person who gets it may not respond in a timely manner.

How will these technologies be used in the process industries?

Instructor-based learning: Classrooms and training centers will continue to teach hands-on skills. Machinists, mechanics, welders and workers in other trades will not learn hands-on skills through a computer. Video screens and computer monitors do not replace touch and feel.

Virtual class: This method is already used for distance universities, with professors lecturing in one city and students attending class in several other locations. These classrooms can be used for applications such as product training, corporate policy or

engineering procedures.

Virtual lecture: This will be most effectively used in conjunction with discussion boards, real-time discussions or chat. Presentations at industry symposiums can be broadcast via the Internet, perhaps to be archived and viewed later. Virtual lecture attendees can discuss the material, ask questions of each other and ask the presenter questions. The most interesting presentations will no longer be one-time events but ongoing industry discussions.

Self-paced: This type of training will be used to deliver the critical facts and information about industrial equipment systems and how the systems operate. It will be used when an employee enters the company to build basic knowledge and as a reference throughout the employee's career. Instead of waiting on the job for three months before the next scheduled training seminar, an employee can begin learning on day one. If the employee has a question on a specialty piece of equipment or one part of an equipment system, the critical facts are available when needed.

Mentoring: Apprenticeship will return to the workplace, but it will be enabled by technology. The "old-timers" will coach newer employees to assist them with their jobs and point them in the right direction to solve problems. In the best case, mentoring occurs in person, but in the era of dwindling resources, the Internet will enable experienced workers (perhaps retired workers) to provide mentoring to many employees in remote locations.

Discussion boards/threaded discussions: Threaded discussions will be used to collaborate, solve problems, agree on policies and document the discussions for later reference. For example, if a plant is having a problem with a unit charge pump, it can initiate a threaded discussion and invite specialists from other plants, operators, maintenance personnel, metallurgists and vendors to participate. The problem-solving process will incorporate input from all disciplines involved to ensure critical information is not being overlooked.

Simulation: Once the domain of airline pilots and nuclear power plant operators, simulations are being used for all types of business skills. Problem solving, project management, leadership and coaching are all being simulated through role-playing scenarios. Simulation goes beyond remembering facts and answering questions, it delivers learning through stories and scenarios and allows application and practice in a safe environment. Scenarios will be used to illustrate common equipment failure modes, how to solve problems and how to prevent them in the future.

Chat: It will be incorporated into virtual classrooms and virtual lectures, allowing students to ask questions, pass ideas back and forth and stay engaged in the discussion.

Real-time discussion: This is similar to chat, and will be used for the same purposes, but the discussion is documented. Equipment professionals can create lively discussion groups online, much like the topic-specific discussions that occur at symposiums. Online discussion may be incorporated into the symposium discussions. When companies are experiencing a significant problem, they can gather groups of personnel from various sites online to work toward a solution.

Study group/buddy system: These are generally informal and form automatically when workers have similar or complementary responsibilities. Groups of employees with similar skill levels and objectives can help each other learn. They may "attend" an online lecture and discuss it with each other. Companies can promote knowledge transfer across plant sites by creating groups that have regular online meetings. The Internet allows these groups to form and meet more efficiently across plant sites around the world.

Help desk: The "desk" will be the technical support department of equipment manufacturers, online assistance from consultants and assistance to employees from e-learning companies. Expert assistance will be immediately available via the Internet to assist in problem solving and provide additional resources.

E-mail lists: These will be used to augment industry publications, delivering content to the desktop in addition to the mailbox. E-mail will notify equipment professionals of upcoming events, new technologies and new training courses available online. Companies can document lessons learned and send the message throughout the organization. E-mail directories of company experts can let new employees know who has the resident knowledge and how to contact the appropriate person.

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