International Journal of Training and Development 7:4
ISSN 1360-3736

E-learning: emerging uses, empirical results and future directions

Elizabeth T. Welsh,
Connie R. Wanberg,
Kenneth G. Brown and
Marcia J. Simmering

The use of network technology to deliver training is the latest trend in the training and development industry and has been heralded as the 'e-learning revolution.' In an effort to separate hype from reality, this paper reviews practitioner and research literature on e-learning, incorporating unpublished information from interviews with managers and consultants directly involved in e-learning initiatives. Specific attention is given to why organizations use e-learning, what the potential drawbacks to e-learning are, what we know from research about e-learning and what the future of e-learning may hold.

> [E-learning] is part of the biggest change in the way our species conducts training since the invention of the chalkboard or perhaps the alphabet. The development of computers and electronic communications has removed barriers of space and time. We can obtain and deliver knowledge anytime anywhere. (Horton, 2000: 6)

Practitioners (Berry, 2000; Coné and Robinson, 2001; Rossett, 2002) and researchers (Brown and Ford, 2002; Salas *et al*., 2002; Steele-Johnson and Hyde, 1997) agree that technological advances are dramatically altering the training and development landscape. In particular, the increased use of Internet technologies to deliver training has been heralded as the 'e-Learning Revolution' (Galagan, 2000: 25). Although precise estimates for growth in e-learning vary, published estimates indicate that organiza-

❒ Elizabeth Welsh, 3-300 Carlson School of Management, 321 19th Avenue S., Industrial Relations Center, University of Minnesota, Minneapolis, MN 55455, USA, e-mail: ewelsh@csom.umn.edu; Connie R. Wanberg, University of Minnesota; Kenneth G. Brown, University of Iowa; Marcia J. Simmering, Louisiana Tech University. Note: the second and third authors contributed equally.

tions have increased and will continue to increase the use of technology to deliver training (Rossett, 2002).

To aid organizations that seek to adopt e-learning, practitioner-focused articles and books have proliferated. Empirical research has been less common, yet some intriguing findings relevant to the use of e-learning have emerged. To date, however, no clear and concise review of the practitioner and academic literature exists. Such a review would allow both professionals and academics to better understand the e-learning trend. Perhaps more importantly, it would help to separate hype and hopes (frequently present in the practitioner literature) from documented findings, thus improving both implementation and research efforts.

In this paper, we present a comprehensive review of the practitioner and research literature on e-learning, incorporating unpublished information from interviews with managers and consultants directly involved in e-learning initiatives. Specifically, our review discusses answers to the following questions:

(1) What is e-learning and how is it being used by organizations?
(2) Why are organizations using e-learning?
(3) What are potential drawbacks of using e-learning? and
(4) What has empirical research found regarding e-learning effectiveness, efficiency, attrition, and appeal to learners?

We end with a speculative discussion about the future of e-learning in organizations.

We gathered information for this review by conducting an extensive literature search and by interviewing practitioners and consultants (subject matter experts with recent experience leading e-learning efforts in major organizations or working full-time in this industry). Our effort was guided by the methods used in prior reviews on newly emerging, under-researched human resources topics (e.g., Schippmann *et al*., 2000).

For the literature review, an article-by-article search was conducted through 28 academic journals and 4 practitioner periodicals[1] for work on or relating to e-learning. Journals published from 1990 through to the end of 2001 were searched. Periodicals were only searched post-1998 because little information was found on the subject prior to that time. Computer databases were also used to identify additional articles, books, and book chapters relevant to e-learning.

For the expert (SME) interviews (N = 22) a wide range of companies[2] were chosen. Most of the individuals who were interviewed were leading e-learning efforts in their organizations. Each SME was asked a consistent set of questions (e.g., 'Give me two specific examples of e-learning that you are using that is asynchronous'; 'When did your organization begin using e-learning and why?'), although questions were modified when appropriate. We draw upon these interviews to provide concrete examples of e-learning in this review.

What is e-learning and how is it being used by organizations?

E-learning can be defined as the use of computer network technology, primarily over an intranet or through the Internet, to deliver information and instruction to individuals (in our case, employees). Our SMEs suggested that while terms such as computer-based learning, on-line learning, distributed learning, or web-based training are sometimes used, e-learning will increasingly dominate as the term of choice in organizations. Some companies and industry experts include knowledge management and virtual collaboration in their definition of e-learning, describing e-learning broadly to include any system that 'generates and disseminates information and is designed to improve performance' (Rosenberg, 2001: 11). While this broader definition is interesting, this article focuses primarily on *training* delivered via network technology, where training refers to planned efforts to increase job-related knowledge and skill (e.g., Noe, 2002).

Most e-learning in organizations today is *asynchronous* in nature. Asynchronous e-learning refers to e-learning that is 'pre-recorded' or available to employees at any time of the day, potentially from any location (Rosenberg, 2001). Less common is *synchronous* e-learning, or e-learning that is 'live' and that requires all learners to be in front

of their computers at the same time. While these kinds of training seem quite distinct from each other and from instructor-led training, the distinction between them is often blurred because many companies use a mix of delivery options for their classes. *Blended classes*, or 'blended learning,' use some combination of technology and classroom-based learning and are becoming a very popular form of training according to our SMEs and the practitioner literature (Elliott, 2002; Zenger and Uehlein, 2001).

Asynchronous e-learning applications vary in terms of sophistication. Less sophisticated asynchronous e-learning applications are often simply Microsoft PowerPoint™ slides posted on a website. More sophisticated applications require learner involvement, including online learning simulations with graphics, animation, video, and audio components (Hall, 1997). While many of our SME organizations began with less sophisticated e-learning applications, they quickly learned that employees typically want more interactivity than that provided by slides on the Web. Additionally, as technology limitations decrease, more complex training can be offered. A few of our SME organizations have found, however, that both basic information provision and complex simulations are useful. Thus, it seems that there may be roles for both simple and complex asynchronous learning experiences in organizations.

One example of asynchronous training in our SME organizations is provided by Dow Chemical's 'Interviewing Training' course for employees who are going to be conducting interviews. In order to keep learners engaged, many different interactive approaches (e.g., hyperlinks and buttons) are used, so that the learner has to interact with the course. Interaction and comprehension are also encouraged by different kinds of testing, including multiple choice and 'drag and drop.' For example, one exercise asks the learner to match actions, like 'compare the candidate's qualifications to the job requirements,' to different interviewer roles, like 'data evaluator.' In order to answer the question, learners drag the action from the right of the screen to match the role on the left of the screen. The system then gives them immediate feedback about whether they answered correctly. The entire class takes about two hours, but learners can stop, save what they have done and come back later to finish. Learners can also take a post-test at any time, and, if they pass, they have completed the class. For this and other e-learning classes, Dow Chemical won ASTD's Excellence in Practice Award for Electronic Learning Technologies (ASTD, 2001).

As with asynchronous e-learning, there is a continuum of types of synchronous e-learning. The most basic type of synchronous learning involves real time 'chat' sessions where employees log on at the same time to discuss training topics. A more complex type is a synchronous session where learners from diverse locations log into the training at a set time, and an instructor facilitates a discussion while showing slides or writing on a 'whiteboard' that appears on the computer screens of the learners. During these sessions, learners can ask questions, sometimes verbally, of the instructor. An example of synchronous e-learning was provided by Accenture, which offers a course in 'Integrated Supply Chain Management'. Synchronous collaboration among team members distributed across the country occurs as they work together to develop and present a case analysis.

Blended learning has many different forms with various mixes of asynchronous, synchronous, and classroom learning. Merck provides one example of such a solution. Previously, when new managers were hired, they attended a new manager orientation program. This one-day, face-to-face program was packed with information, and there was limited time for manager skills training. To solve this problem, Merck introduced a blended learning solution that is partially Web-based and partially classroom-based. The new managers complete e-modules on various topics before coming to a classroom session. The classroom-based training is then used for the interactive elements of the training, such as role-plays and discussion.

Why are organizations using e-learning?

Organizations are choosing e-learning for a variety of reasons including the desire to:

(1) provide consistent, worldwide training;
(2) reduce delivery cycle time;
(3) increase learner convenience;
(4) reduce information overload;
(5) improve tracking; and
(6) lower expenses.

These benefits are summarized below.

E-learning appeals to organizations that have a strong need or desire to deliver consistent training across multiple locations. For example, Dow Chemical had a 'Respect and Responsibility' class that employees at all locations were supposed to take, but implementation was left to each location to allow for adaptation to local cultural norms. What Dow found was that many locations were not conducting the training, and when the training was occurring, the messages delivered were often inconsistent and poorly communicated. Dow's 'Respect and Responsibility' course is now conducted, almost entirely, through asynchronous e-learning. Dow avoids problems that could be introduced if location-specific needs were ignored by providing local classroom training after the asynchronous training has been completed.

Companies also use e-learning when they are pushed to deliver training to many people quickly. Because e-learning classes are not constrained by instructor and classroom capacity, more people can be trained in less time. If 1,000 people need to be trained for five days, but there is only one classroom with a capacity of 20, it will take 50 weeks to deliver the class. However, if delivered through e-learning, the class could theoretically be delivered to everyone in a single week. This capability can also be used to establish a competitive advantage in sales. For example, Nokia delivers new product information to their dealers using e-learning. With a two-stage process of content development and translation, Nokia develops and makes available, via the Internet, product specifications in 22 different languages. The entire process takes only 12 weeks.

Another benefit of e-learning is increased learner convenience. Provided that they have the required technology, learners have access to asynchronous e-learning at any time. For example, if a manager is preparing to conduct interviews for an open position, she can complete a short interview skills course the morning of the interview. To facilitate such just-in-time use of training, synchronous courses are frequently archived so that they can be accessed when needed by learners.

E-learning also has the potential to manage the growth in the amount of information that employees need to learn. This growth has often led to information overload during training, resulting in ineffective training when learners cannot retain all of the information presented to them. By conducting part of the training asynchronously, part of it synchronously, and only the most interactive part in a classroom, the information can be delivered over a longer period of time. This is thought to improve retention. This potential advantage is rarely cited in the literature but was mentioned frequently by our SMEs. For example, American Airlines was experiencing an 18% attrition rate of ticket and gate agent trainees in part because they were being overwhelmed by the amount of information given to them in classroom-based training. To solve this problem, American Airlines adopted a blended e-learning solution, combining self-paced asynchronous learning with classroom learning. Learner reactions to the training improved, and turnover decreased following implementation. This solution won the American Society for Training and Development Excellence in Practice Award (ASTD, 2000).

Another potential advantage of e-learning systems is their ability to track learner activities and mastery of the material (e.g., through quiz scores). Many companies, before e-learning, did not track such data because of the effort required to do so. With e-learning, tracking and storing can be automated. This is particularly beneficial when training is required for compliance. For example, Best Buy tracks which employees take required safety classes and whether the employees are certified. However, one complication with tracking e-learning was noted. A company can never be certain that the proper person completed the training. A manager, for example, could ask his

assistant to complete a sexual harassment course and the system would be unable to detect this deception.

Organizations are also turning to e-learning as a cost-saving measure, particularly when they want to reduce travel and classroom costs, and time off-the-job, associated with off-site training. An example from our SME organizations is Dow Chemical, which estimates that it saved $30 million in 2000 by implementing an asynchronous, Web-based system (*Dow Chemical Company, 2002 Enterprise Value Awards*, 2001). Approximately $20 million of the savings was due to a reduction in the time employees spent in training, with the additional $10 million of savings due to a reduction in administrative time, cost of classroom facilities and facilitators, and cost of printed materials. A similar pattern of savings occurred at Rockwell Collins. However, the initial investment required to develop a highly interactive e-learning course can be high, so cost savings are certainly not automatic. We address this issue along with other research findings relating to e-learning effectiveness and efficiency in a following section.

What are potential drawbacks of using e-learning?

While the potential advantages of e-learning make it appealing, organizations embarking on e-learning implementations must keep two things in mind: there are a number of potential drawbacks to using e-learning, and successful implementation requires significant planning and effort. We will first briefly review potential drawbacks and then discuss implementation issues noted by our SMEs.

Up-front cost was the most frequently mentioned drawback of e-learning. E-learning initiatives can require considerable investment in both information technology (IT) and staff. Specific costs include development costs to design and build the actual courses as well as hardware and software costs to allow users to access the training.

Many of the SMEs also expressed concern about the lack of interaction among trainees in many e-learning courses. Accenture, for example, indicated that the lack of peer-to-peer networking makes e-learning less attractive to its learners and potentially less useful. While these SMEs acknowledged that peer-to-peer interaction is not impossible via network technology (e.g., Accenture's 'Integrated Supply Chain Management' course noted earlier), they recognized that it is resource intensive.

A few of the SMEs were also concerned that the use of static and non-interactive e-learning may create a mindset that electronically-encoded information *is* training. In other words, the concern is that top management will become preoccupied with the capability to push information and will forget that training involves more than information provision; it requires practice, feedback, and guidance. Dobbs (2002) appropriately titles a section of a chapter he wrote on e-learning 'Quit pretending that reading is training' (p. 358).

Beyond these potential drawbacks, our research makes one additional point very clear: effective e-learning requires significant effort and planning. If sufficient attention is not given to implementation, e-learning will not be successful. In fact, while many companies have experienced success with their e-learning efforts, others have aborted their efforts (e.g., NYNEX; Howard, 1998).

Our SME interviews and literature review highlighted three areas that need to be considered during implementation planning: training design, information technology (IT) infrastructure, and change management. Important design issues include whether employees can use the technology, how to ensure well designed learning events (incorporating adult learning principles) and how to ensure learner motivation. Important IT issues include whether users have the technology necessary to access content and whether the required resources, including hardware, software and technical support for both launch and maintenance, are available. Finally, important change management issues include how to prepare users and training department staff for the change and how to gain and sustain senior management support of the initiative.

Hype versus documented findings: a look at empirical research on e-learning

We have detailed reasons companies give for shifting courses away from the classroom to the Internet or another form of technology delivery and some potential disadvantages of this shift. However, to what extent does empirical research support the use of e-learning? We have compiled published empirical research relevant to the effectiveness (does e-learning stimulate learning?), efficiency (to what degree do these programs use resources efficiently?), attrition (what is the level of drop-out in such training?) and appeal (how do learners react to the training?) of technology-delivered training in this section.

Our review includes empirical studies published between 1990 and 2001 that were focused on job-relevant training for adults and delivered primarily by technology. Most relevant research published prior to 1990 is summarized elsewhere (Kulik and Kulik, 1991), and technology advances limit its relevance. Research on a variety of technologies, ranging from audio-conferencing to complex simulations, was included, following directly from ASTD's recognition that e-learning involves 'the delivery of content via the Internet, intranet/extranet, audio- and videotape, satellite, broadcast, interactive TV, or CD-ROM' ('An E-learning Survey,' 2001: 75), and because these technologies are embedded as sole or combined technologies in today's e-learning implementations (e.g., intranet delivered video). Based on these criteria, we identified 27 studies. Results of these studies are summarized next, and in cases where research gaps exist, we rely on SME comments and provide suggestions for further research.

Effectiveness

There are four important questions about effectiveness that have been addressed at least in part by empirical research:

(1) Can adults learn from classes conducted through technology?
(2) Are classes conducted through technology equally effective for everyone?
(3) Are classes conducted through technology equally effective for all types of courses? and
(4) Are such classes better than or at least as good as classroom training?

First, research suggests that people can and do learn from technology-delivered instruction. Brown (2001), for example, demonstrated that manufacturing employees taking an intranet-delivered course improved their knowledge substantially from pre- to post-test. O'Hara (1990) found that computer-delivered simulations helped future US Maritime Officers improve their job-specific decision-making skills. Similarly, Gopher *et al*. (1994) found that practice in a low-fidelity simulation improved most measures of cadets' subsequent flight performance as compared to a group who did not use the simulation. Bramble and Martin (1995) found that five technical courses (e.g., typing, handling hazardous waste) using two-way interactive video were effective for improving content-related achievement tests. Baker (1992) found that a computer tutorial given to truck and bus drivers helped improve their test performance on a federally mandated exam, and improved their reading levels. North *et al*. (2000) found that teachers were able to effectively complete training-related exercises after completing a class delivered primarily via CD-ROM.

A second question with regard to effectiveness is whether e-learning is equally effective for everyone. Studies involving instructor-led training on computer skills, such as Martocchio (1994) and Gist *et al*. (1989), suggest that lower levels of computer self-efficacy are related to lower learning outcomes. Although it is difficult to infer the generalizability of instructor-led computer skills training to e-learning that is not focused on computer skills, these studies at least suggest that learners with low computer self-efficacy, or with anxiety regarding computers, may have difficulty using the computer

as a learning tool. Our SME interviews reinforce these concerns. However, because computers have become more prevalent in recent years, younger employees might be expected to be more experienced and efficacious with computers, and therefore more suited to e-learning. Moreover, employees in industries where computer use is the norm may generally be more capable and comfortable using computers to learn. It is possible that in circumstances where employees have some minimal familiarity with computers, there are other more powerful factors determining learning outcomes, such as the motivation of the learners, the quality of the course design, and the support made available in the organization. Empirical research specifically examining these factors in the e-learning context is needed.

The review also identified studies indicating that learning style and gender do not substantially determine whether e-learning is effective. Larsen (1992) found no differences in post-test scores based on learner style preferences and Kass *et al*. (1998) found that using computer simulators actually eliminated a gender gap that was present when 'manual only' learning was used.

A third question with regard to effectiveness is whether e-learning is equally effective for all types of courses. In their meta-analysis, Kulik and Kulik (1991) found support for the idea that computer-based instruction might work better in some situations than others. They found that computer-delivery is most effective in short courses (1–4 weeks as compared to 5 or more) with less technical content (social science and reading as compared to science and math). However, these findings were based primarily on studies in academic settings with technology that is now at least 12 years old, so they should be interpreted with caution.

Based on our SME interviews, e-learning may be most useful when the training emphasizes cognitive learning outcomes, particularly less complex knowledge and intellectual skill. One SME that we interviewed found that basic and intermediate skill level classes work well, as do classes that are more conceptual in nature. However, there is concern that more advanced classes or those that require soft skills (e.g., conducting a feedback session) may not be as effective with e-learning. A major limitation for many organizations is that their technology simply cannot handle the requirements of advanced simulations or interaction. In addition, as some of our SMEs noted, classes that teach skills with a psychomotor component, such as throwing a ball or performing surgery, are currently inappropriate for e-learning. The declarative elements of these skills can be taught (e.g., what to call the surgical instruments), but not the procedural element (e.g., how to use the instruments).

Finally, how do the learning outcomes compare between classes conducted through technology and those conducted in a classroom? The literature available generally leads the reader to the conclusion that technology-delivered instruction is, on average, slightly better than classroom training. However, because some studies have not found any difference and because of methodological difficulties contrasting different training sessions, we draw the conclusion that technology-delivered training *can* be more effective than classroom training rather than concluding that it *is* on average better. Evidence for the relative effectiveness of technology is reviewed first, followed by questions regarding the validity and utility of providing a simple answer to this question.

Meta-analyses of this literature support the conclusion that technology is, on average, slightly more effective than the classroom. Kulik and Kulik (1991), for example, found that the average standardized difference between the computer-based training outcomes and classroom training outcomes was 0.25 for the seven studies that examined adults. This means that learners using technology scored, on average, 1/4 of a standard deviation higher on post-tests than learners in instructor-led courses. In a more recent meta-analysis that specifically examined adults in video-delivered instruction, a smaller advantage was found (Machtmes and Asher, 2000). The average effect size estimated from this study is 0.10, based on 19 studies.

In the review conducted for this paper, studies also tended to report better results for technology-delivered training than for classroom training. For example, Janniro

(1993) found that police investigators learning polygraph interpretation learned basic material more effectively via computer than in the classroom. Wisher and Priest (1998) found that first-time passing rates of US National Guard personnel randomly assigned to audio-conferencing delivered training were higher than those randomly assigned to classroom training. Keene and Cary (1990) found that US Army Reserve officers learned operations and logistics materials more effectively via various technology-delivered instructional modules than via classroom lecture. Orey *et al*. (1998) found that US Army officers trained to repair radios with an intelligent tutoring system performed more effectively on post-tests and follow-up retention tests than officers trained in pairs with an instructor present.

Despite these positive findings, our review also revealed studies with mixed results. For example, when studying US Army engineers, Phelps *et al*. (1991) found higher post-test scores in a computer-mediated engineering course, but no significant difference in scores between computer-mediated and classroom delivery for a career advancement course. Similar to these latter findings, two studies we identified reported no significant difference between technology-mediated and classroom-based courses (Whetzel *et al*., 1996; Wisher and Curnow, 1999). An ongoing narrative review of distance education research supports these 'no significant difference' findings; it indicates that most studies find no learning outcome differences across different delivery technologies (Russell, 2002).

While the results of the meta-analyses and the Russell (2002) report may sound contradictory, they reveal the underlying difficulty of research in this area. Comparisons between classroom-based and technology-delivered training are difficult to interpret because of numerous, potential confounds (Clark, 1994). It is difficult if not impossible to create training that is identical in all ways except for the means of delivery. For example, the Janniro (1993) study compared an old classroom version of a course to a revised and better-designed technology-delivered version. Therefore, the difference that was found might have been due, at least in part, to course design rather than the use of technology. Thus, studies that show one medium to be better than another should be interpreted with caution; there may be causes other than technology that lead to the differences.

Another reason for caution in this area is that there are surely moderators or 'contingencies' that influence whether a particular medium or a particular instructor is more effective. The most obvious is quality of instructional design and delivery. Most people would agree that classroom instructors vary in how effectively they gain and keep the attention of learners, demonstrate key points, clarify misunderstandings, offer opportunities for practice, and provide clear and concise feedback. This point is also true for technology-delivered courses. For technology to be effective, it must deliver well-designed instruction in a manner that facilitates (and does not inhibit) learners' motivation and effort (Brown and Ford, 2002). Other possible contingencies are that particular learners and particular content may be more suited to a particular medium or technology. Unfortunately, research is still needed to determine when any one particular technology is more appropriate than others.

In conclusion, available research suggests that many different forms of technology-delivered instruction, ranging from inexpensive technologies, such as audio-conferencing and low-fidelity simulators, to intelligent tutoring systems, *can* be effective in teaching adults. However, we note the dearth of research that has examined potential individual difference, instructional design, and situational moderators of effective e-learning outcomes. More research here would increase our understanding of when it is best to use e-learning as a tool, and how to ensure e-learning effectiveness when it is used. Thus, the answer to the question 'which is more effective: technology or the classroom' is best answered as follows:

> . . . [T]his is a question that is not worth pursuing further. . . . Provided the medium is well-chosen and functioning effectively, it plays only a minor role in affecting learning outcomes, in general. The more valuable questions to research are . . . what type of students learn best in one environment, or in one medium . . . [and] what are the types of information or other educational messages that can be better communicated by one medium than another? (Moore and Kearsley, 1996: 65).

Efficiency

To what extent does e-learning use resources efficiently? To answer this question we begin with a discussion of direct monetary costs and savings associated with e-learning versus classroom training, considering a number of different costs. A primary fixed cost for both e-learning and classroom training is the initial development of the course. E-learning course development costs have the potential to be considerably higher than costs for classroom training (e.g., Chapnick, 2001). Also to be considered is whether the organization must purchase computers or develop an e-learning 'resource area' for employees. To the extent that an organization needs to make these investments, the costs will be higher.

Calculations show, however, that e-learning has the potential to be less costly than classroom training once the course has been developed (Phelps *et al*., 1991; Whalen and Wright, 2000; Wisher and Priest, 1998). While e-learning may involve some expensive variable costs (costs incurred each time the training is repeated) such as technical support, it eliminates several variable costs associated with the classroom, such as travel, lodging, meals, materials, and for some courses, the instructor's salary. Thus, research suggests that e-learning has the potential to be less expensive than classroom training if there are a large number of learners, if the learners are geographically dispersed, and if the course will be repeated several times.

The second area of potential cost savings are indirect – those that occur because employees using e-learning may require less time to learn than those who learn in a classroom. At this point, research has not addressed in sufficient detail whether there are any cost savings due to reduced learning time. While some reduction in learning time has been reported, it could easily be a result of substantial course redesign rather than reduction in class time due to technology. For example, Janniro (1993) reported a 56% reduction in learning time for computer-delivered instruction, but this occurred following a major course redesign. As one of our SME's said, 'We push (designers) to really focus on the few things they want people to learn' when designing e-learning courses. In addition, while Kulik and Kulik (1991) claimed an overall reduction in time for computer over instructor-delivery of 30%, a more detailed examination of the findings indicates that for adult classes there may not have been any reduction in time (see Table 4, p. 87). Supporting this, North *et al*. (2000) reported that teachers took an average of 186 minutes to complete a CD-ROM delivered course, as compared to the expected time of 180 minutes for the classroom version.

The North *et al*. (2000) study hints at an interesting finding regarding this time to completion. A *post hoc* analysis indicated that learners with prior IT skills completed the course in 168 minutes, but those without such skills took 199 minutes. Thus, the results suggest that efficiencies in time may depend in part on the level of experience learners have with the technology. When learners do not have the relevant IT experience, training may actually take longer via technology than it would in a classroom. In addition, technical and social factors may increase the time necessary to complete technology-delivered courses. Both North *et al*. (2000) and Gold (2001) reported time lost due to technology problems and interruptions.

As a final note, we caution that simple cost comparisons may be misleading; e-learning allows companies to do things they would not be able to do under a classroom model (e.g., just-in-time training). Such capability, used properly, may provide substantial business advantages, although we were unable to find research documenting them. With that caveat in mind, we conclude that e-learning may be cost-efficient for courses with many learners dispersed geographically, assuming development costs are reasonable or can be amortized over many administrations of the same course. Further research should investigate time to learn comparisons, time lost due to technology problems, and the business benefits of just-in-time training.

Attrition

Completion rates are often noted as potentially problematic with technology-delivered instruction and are therefore of concern to practitioners (Frankola, 2001; Moshinskie,

2002). Regrettably, completion rates are not always reported in academic research. However, what has been reported suggests that attrition can be a problem, but not an insurmountable one.

Our review suggests that in studies where there was no powerful rationale for completing a course, completion rates for technology-delivered training were lower than those for instructor-led classes. For example, Phelps *et al*. (1991) found a 95% completion rate for US Army Reserve officers taking an engineering course in a classroom, but only a 64% completion rate for those taking the course via computer. For a career advancement course reported in the same study, there was a less dramatic difference (95% classroom, 90% computer). Our SMEs have also found completion of e-learning courses to be less than desirable at times. For example, Best Buy has found that for courses that are not required, participation has been lower than expected. Similar problems were encountered at Nokia.

However, when they have a clear rationale for completing a course, learners generally seem to do so. Wisher and Priest (1998) found no difference between instructor-led and technology-delivered training in a study of military personnel who were completing a vocational course required for a desired promotion. In this case, completion rates were 100% for both groups, perhaps because learners were in a course that was instrumental for transitioning to a new career. Speculation about this point was supported by our SME interviews. Companies that had some form of accountability and/or incentive for learners to complete the training, whether it was eventual participation in a classroom session, advancement towards a development goal, payment of overtime, or the use of a tracking system, did not have significant problems with completion rates. Also, strong job-relevant and useful course content appears to be an adequate incentive for learners. In contrast, it seems that if courses are perceived to be optional or have little impact on the learner, lower completion rates will likely occur.

An interesting question regarding completion – whether completion was necessary in order for employees to learn what they needed to – was raised by the Nokia SME. It was this SME's belief that employees may use courses as quick job aids. If this is the case, then employees may only complete a small portion of a course but find exactly what they need. As a consequence, Nokia tracks and manages enrollments rather than completions. Nokia's efforts raise the question of whether employees use e-learning for training, performance support, or a combination of both. Research on this question would be useful.

Appeal

Finally, practitioners must consider whether employees will want to take computer-based classes. Findings from research indicate that as long as technical difficulties are not overwhelming, after participating in a technology-mediated class, participants have more positive attitudes about technology-mediated classes, are satisfied with their learning experience and are willing to use it again. For example, Gold (2001) found that teachers who took an online course reported more positive attitudes toward online instruction after completion. Heinzen and Alberico (1990) reported that participants across industries and professions generally reported improved perceptions regarding teleconferencing following its use. More specifically, users indicated an increased belief that teleconferencing could be used to enhance skill, motivation, and communication. Johnson *et al*. (2000) reported that 98% of the participants in a continuing dental education course delivered via two-way video would attend another class that used that method. However, Bramble and Martin (1995) reported mixed perceptions across different courses offered in the US armed services. The cause of these differences was unclear.

Generally, therefore, e-learning can be a positive experience. However, if the technology does not work well, it has the potential to become a very negative experience. North *et al*. (2000) reported that teachers were very frustrated with CD-ROM training when that training had technical errors. When problems were not resolved within ten

minutes, teachers quit with 'extremely strong feelings of frustration or anger' (p. 32). This issue was raised numerous times during the SME interviews. If the technology did not work well the first time someone used it, the individual would become resistant to taking another course this way (see also Rossett, 2002).

Empirical research: conclusions

Although our research review raised many questions and suggests the need for more research, we draw the following four conclusions. First, research to date suggests that most people can learn effectively from technology-delivered courses, although comparisons between technology-delivery and the classroom should be viewed with caution. Second, available research suggests technology can reduce training costs if there are a large number of learners, if the learners are geographically dispersed, and if the course will be repeated several times. Third, it appears that if courses are perceived as optional or have little impact on the learner, low completion rates are likely. Moreover, in some situations, completion of the entire e-learning course may not be necessary if the employee can get what he/she needs from part of a course. Finally, research suggests that adults generally have positive attitudes towards technology-delivered classes. However, organizations need to take care to avoid technology-related problems and interruptions, which may increase learner frustration.

What is the future of e-learning?

In this review, we have emphasized current practice and research in e-learning, and we now turn to the future of e-learning. Based on SME interviews, we identified four themes:

(1) growth in synchronous learning;
(2) prevalence of blended solutions;
(3) improved technology and access; and
(4) integration of information provision, performance support, peer collaboration, and training.

Many of our SMEs indicated that synchronous solutions were becoming more prevalent in their organizations as they perceive this feature to be underutilized. As the technology improves, our experts predict that more classes will be mediated via the Internet and corporate intranets.

The increase in synchronous solutions fits hand-in-hand with the trend toward increasingly blended solutions that use a combination of asynchronous, synchronous and classroom experiences. In fact, several SMEs believe that some form of technology will become the norm in nearly all training efforts. An interesting corollary to this point is that instructors and the classroom will continue to play important roles in training.

Not only did the SMEs predict that e-learning would increase, but they expected the technology used for it to improve and be further reaching. For example, wireless training, sometimes called 'm-learning,' for mobile learning that can be transported anywhere with a personal digital assistant (or 'PDA'; Polivka, 2001), is expected to increase in popularity. As one example, Rockwell Collins is piloting PDA delivery of 'how to' videos to employees working in manufacturing settings.

In addition, according to our SMEs, Rossett (2002), and Rosenberg (2001), the future of e-learning is in the integration of information management (including training content material, the learner's current knowledge, and the learner's training activities, often now distinctly referred to as content management, knowledge management, and learner management systems), performance support, peer collaboration, and training systems. For example, in the future, a sales employee should be able to use a single intranet portal to collect information about potential customers, find a quick answer to a customer query, interact with other sales staff throughout the country, and take a class about sales techniques.

Conclusion

Our goal was to present a comprehensive review of the e-learning movement. We described many examples of e-learning and discussed several reasons why organizations are developing e-learning solutions as well as the potential drawbacks of e-learning. Our review of the academic research on e-learning revealed the use of e-learning moving faster than our empirical understanding of e-learning. Nevertheless, the practitioner and research literatures together suggest that technology *can* be used effectively and efficiently to facilitate learning. To do so, however, an organization must carefully consider issues of training design, IT infrastructure, and change management.

Notes

[1] *The Academy of Management Journal*; *ACM Transactions on Human-Computer Interaction*; *The American Journal of Distance Education*; *Computers and Human Behavior*; *Educational Technology Research and Development*; *E-Learning Magazine*; *Ergonomics*; *HR Magazine*; *Human Factors*; *Human Performance*; *Human Resource Development Quarterly*; *Human Resource Management Journal*; *International Journal of Human-Computer Studies/Knowledge Acquisition*; *Interactive Multimedia Electronic Journal of Computer-Enhanced Learning*; *Journal of Applied Psychology*; *Journal of Asynchronous Learning Networks*; *Journal of Computer-Assisted Learning*; *Journal of Computer-based Instruction*; *Journal of Computer-Mediated Communication*; *Journal of Distance Education*; *Journal of Educational Psychology*; *Journal of Educational Media*; *Journal of Experimental Psychology: Applied; Journal of Experimental Psychology: Learning, Memory, and Cognition; Journal of Management*; *Journal of Management Education*; *Journal of Vocational Behavior*; *Journal of Vocational Education Research*; *Personnel Psychology*; T*raining and Development Magazine*; *Training Magazine*; and *Training Research Journal*.

[2] Accenture; American Airlines, Inc.; Best Buy Co., Inc.; Carley Corporation; ChevronTexaco Corp.; The Dow Chemical Company; Dow Corning Corporation; eLearnia, Inc.; GE Capital; Guidant Corporation; IBM Corporation; Medtronic, Inc.; Merck and Co., Inc.; Nokia; Nucleus Technologies, Inc.; Rockwell Collins, Inc.; Royal Dutch/Shell Group; TRW, Inc.; Unilever N.V.; United Parcel Service, Inc.; two companies asking not to be named.

References

An E-Learning Survey (2001), *T+D*, **55**, November, 74–7.

ASTD (2000), 2000 Excellence in Practice Award and Citation Winners Awards: American Airlines FlagShip University: Taking new hire training to new heights. Award in Technical Training. Retrieved May 23, 2002, from http://www.astd.org/virtual_community/awards/2000_award_winners.html.

ASTD (2001), 2001 Excellence in Practice Award and Citation Winners Awards: The Dow Chemical Company: Learn@Dow.now. Award in Electronic Learning Technologies. Retrieved August 23, 2002, from http://www.astd.org/virtual_community/awards/2001_award_winners.html.

Baker, G. (1992), Application report: Instructional design of a computer-assisted work-related literacy program. *Journal of Computer-based Instruction*, **19**, 33–6.

Berry, J. (2000), Traditional training fades in favor of e-learning. *Internetweek*, **800**, 14 February, 33–5.

Bramble, W. J. and Martin, B. L. (1995), The Florida Teletraining Project: Military training via two-way compressed video. *American Journal of Distance Education*, **9**, 6–26.

Brown, K. G. (2001), Using computers to deliver training: Which employees learn and why? *Personnel Psychology*, **54**, 271–96.

Brown, K. G. and Ford, J. K. (2002), Using computer technology in training: Building an infrastructure for learning. In K. Kraiger (ed.), *Creating, Implementing, and Managing Effective Training and Development* (pp. 192–233). Mahwah, NJ: Jossey-Bass.

Chapnick, S. (2001), E-learning? Show me the money! *T+D*, **55**, June, 76–9.

Clark, R. E. (1994), Media will never influence learning. *Educational Technology Research and Development*, **42**, 21–9.

Coné, J. W. and Robinson, D. G. (2001), The power of e-performance. *T+D*, **55**, August, 32–41.

Dobbs, K. (2002), The state of online learning – what the online world needs now: Quality. In A. Rossett (ed.), *The ASTD E-learning Handbook* (pp. 357–72). New York: McGraw-Hill.

Dow Chemical Company (2001), *2002 Enterprise Value Awards*. Midland, MI.
Elliott, M. (2002), Blended learning: The magic is in the mix. In A. Rossett (ed.), *The ASTD E-learning Handbook* (pp. 58–63). New York: McGraw-Hill.
Frankola, K. (2001), Why online learners drop out. *Workforce*, **80**, October, 53–60.
Galagan, P. A. (2000), The e-learning revolution. *T+D*, **54**, December, 24–30.
Gist, M. E., Schwoerer, C. and Rosen, B. (1989), Effects of alternative training methods on self-efficacy and performance in computer software training. *Journal of Applied Psychology*, **74**, 884–91.
Gold, S. (2001), A constructivist approach to online training for online teachers. *Journal of Asynchronous Learning Networks*, **5** (*1*). Retrieved October 25, 2001, from http://www.aln.org/alnweb/journal/Vol5_issue1/Gold/gold.htm.
Gopher, D., Weil, M. and Bareket, T. (1994), Transfer of skill from a computer game trainer to flight. *Human Factors*, **36**, 387–405.
Hall, B. (1997), *Web-based Training Cookbook*. New York: John Wiley and Sons.
Heinzen, T. E. and Alberico, S. M. (1990), Using a creativity paradigm to evaluate teleconferencing. *American Journal of Distance Education*, **4**, 3–12.
Horton, W. (2000), *Designing Web-based Training*. New York: John Wiley and Sons.
Howard, B. (1998), Increasing employee knowledge and understanding of operational systems: Integrating multiple technologies at NYNEX. In D. A. Schreiber and Z. L. Berge (eds), *Distance Training: How innovative organizations are using technology to maximize learning and meet business objectives* (pp. 92–114). San Francisco, CA: Jossey-Bass.
Janniro, M. J. (1993), Effects of computer-based instruction on student learning of psychophysiological detection of deception test question formulation. *Journal of Computer-based Instruction*, **20**, 58–62.
Johnson, L. A., Lohman. M. C., Sharp, J. D. and Krenz, T. C. (2000), Continuing dental education via an Interactive Video Network: Course development, implementation and evaluation. *Journal of Educational Media*, **25**, 129–40.
Kass, S. J., Ahlers, R. H. and Dugger, M. (1998), Eliminating gender differences through practice in an applied visual spatial task. *Human Performance*, **11**, 337–49.
Keene, S. D. and Cary, J. S. (1990), Effectiveness of distance education approach to U.S. Army Reserve component training. *American Journal of Distance Education*, **4**, 14–20.
Kulik, C. C. and Kulik, J. A. (1991), Effectiveness of computer-based instruction: An updated analysis. *Computers in Human Behaviors*, **7**, 75–94.
Larsen, R. E. (1992), Relationship of learning style to the effectiveness and acceptance of interactive video instruction. *Journal of Computer-based Instruction*, **19**, 17–21.
Machtmes, K. and Asher, J. W. (2000), A meta-analysis of the effectiveness of telecourses in distance education. *American Journal of Distance Education*, **14**, 27–46.
Martocchio, J. J. (1994), Effects of conceptions of ability on anxiety, self-efficacy, and learning in training. *Journal of Applied Psychology*, **79**, 819–25.
Moore, M. G. and Kearsley, G. (1996), *Distance Education: A systems view.* Belmont, CA: Wadsworth.
Moshinskie, J. (2002), How to keep e-learners from e-scaping. In A. Rossett (ed.), *The ASTD E-learning Handbook* (pp. 218–33). New York: McGraw-Hill.
Noe, R. A. (2002), *Employee Training and Development* (2nd edn). Boston: McGraw-Hill.
North, R. F. J., Strain, D. M. and Abbott, L. (2000), Training teachers in computer-based management information systems. *Journal of Computer-Assisted Learning*, **16**, 27–40.
O'Hara, J. M. (1990), The retention of skills acquired through simulator-based training. *Ergonomics*, **33**, 1143–53.
Orey, M., Zhao, R., Fan, H. and Keenan, R. (1998), Summative evaluation of the SINCGARS Tutor. *Computers in Human Behavior*, **14**, 579–95.
Phelps, R. H., Rosalie, A. W., Ashworth, R. L., Jr. and Hahn, H. A. (1991), Effectiveness and costs of distance education using computer-mediated communication. *American Journal of Distance Education*, **5**, 7–19.
Polivka, B. (2001), m-learning: The next big thing. *e-learning*, **2**, May, 30–3.
Rosenberg, M. J. (2001), *E-learning: Strategies for delivering knowledge in the digital age*. New York: McGraw-Hill.
Rossett, A. (2002), Waking in the night and thinking about e-learning. In A. Rossett (ed.), *The ASTD E-learning Handbook* (pp. 3–18). New York: McGraw-Hill.
Russell, T. L. (2002), *The 'no significant difference phenomenon.'* Retrieved July 17, 2002, from http://teleeducation.nb.ca/nosignificantdifference.
Salas, E., Kosarzycki, M. P., Burke, C. S., Fiore, S. M. and Stone, D. L. (2002), Emerging themes in distance learning research and practice: Some food for thought. *International Journal of Management Reviews*, **4**, 135–53.

Schippmann, J. S., Ash, R. A., Battista, M., Carr, L., Eyde, L. D., Hesketh, B. *et al*. (2000), The practice of competency modeling. *Personnel Psychology*, **53**, 703–40.
Steele-Johnson, D. and Hyde, B. G. (1997), Advanced technologies in training: Intelligent tutoring systems and virtual reality. In M. A. Quinones and A. Ehrenstein (eds), *Training for a Rapidly Changing Workplace: Applications of psychological research* (pp. 225–48). Washington, DC: American Psychological Association.
Whalen, T. and Wright, D. (2000), *The Business Case for Web-based Training*. Norwood, MA: Artech House.
Whetzel, D. L., Felker, D. B. and Williams, K. M. (1996), A real world comparison of the effectiveness of satellite training and classroom training. *Educational Technology Research and Development*, **44**, 5–18.
Wisher, R. and Curnow, C. K. (1999), Perceptions and effects of image transmissions during Internet-based training. *American Journal of Distance Education*, **13**, 37–51.
Wisher, R. and Priest, A. N. (1998), Cost-effectiveness of audio teletraining for the U.S. Army National Guard. *American Journal of Distance Education*, **12**, 38–51.
Zenger, J. and Uehlein, C. (2001), Why blended will win. *T+D*, **55**, August, 54–60.

