Evaluating Technology and Instruction: Literature Review Update

December 11, 2004

Kelly Alanis

The University of Texas at Austin
Division of Instructional Innovation and Assessment

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Executive Summary

This review of the vast literature related to technology and e-Learning in higher education from 2002 to 2004 illustrates that there has been considerable research in this area: in a flourish reminiscent of the dot-com boom, the “dot-edu” boom (Pittinsky, 2003) burst onto the scene. Providers and technical innovators appeared in droves vying to get in on the limitless potential of e-Learning.

But as with most innovations, speculation out-distanced reality. Murmurs of discontent began to spread—e-Learning was not the solution to all the ills of higher education. Institutions that had made huge investments in technology began to question the wisdom of their decisions, and providers and technical innovaters began to lose faith.

While the spotlight has dimmed on e-Learning, proponents say that this boom-bust cycle is normal for innovations. They are confident that the cycle of adoption will weed out less stable, less enduring products, services, and providers. A new industry of e-Learning will result with products and providers tried and tested.

The literature is dominated by this theme. Why has e-Learning failed? What does it look like when it works well? Five themes have emerged in answer to these questions:

- Projections could not be realized due to overdevelopment of e-Learning products and services based on market speculation.
- Providers and institutions that invested in the technology have grown disillusioned in the face of lack of technical support.
- Product users have grown disillusioned in the face of lack of training and development.
- Financial support has been insufficient.
- Pedagogy has been slow to adapt.

These themes are supported in a recurrent finding—technology will not work unless it is deployed well at each phase of the integration of technology and teaching, from the choice of products to the appropriate training of the end-users to the realization of the pedagogical principle that learning goals must dictate choice of technology. More than simply training faculty in the technical aspects of a product or service, we must help them learn how to integrate technology so as to maximize learning, engagement, participation, and satisfaction.

Deploying technology properly requires long-range planning, collaboration, and cooperation from everyone affected by the innovation, with recognition of several major considerations for success with e-Learning:

- Teaching with technology is different. We must not make the mistake of trying to map traditional materials into the new technology space.
- Interaction is critical. Because using technology provides great potential for supporting interaction, instructors who maximize this potential create a more authentic learning environment.
- Learning goals are primary. So, rather than trying to fit available technology, learning goals should dictate the choice of technology.
- Pre-planning is essential. At all phases in the adoption network, collaboration, cooperation, and creativity are vital.
- Faculty need development. Training must be provided not only in the technical aspects of the technology but in how to use these new tools pedagogically.
- Students need scaffolding. By assuring students' comfort and proficiency within the new learning environment created with the new technology, we are paving the way for the adoption of and facility with other technologies and innovative teaching methods.

Though proper deployment requires extensive work, the rewards, in terms of student and faculty satisfaction and return on investment, are summarized by four themes emerging in the literature:

- *e-Learning stacks up well against traditional educational techniques.* In spite of the classic better-worse-no significant difference debate, research is valuable for demonstrating the viability of e-Learning technologies and their use as educational tools.

- *Interactivity is a key component of efficient learning in any educational situation.* Interactive learning is not a new pedagogical issue. Abundant evidence suggests that e-Learning is uniquely able to promote interactive learning; in fact, e-Learning demands it.

- *e-Learning can accommodate multiple learning styles.* Some of the literature supports the notion that e-Learning technologies break out of the "one-size-fits all" mode of education and can reach students with very divergent learning styles.

- *e-Learning can be cost effective.* Preliminary findings provide evidence that e-Learning, when applied properly, is cost effective and is likely to provide educational institutions a good return on their investment.

Introduction

The use of technology in teaching and learning continues to receive serious scrutiny. The literature is rife with explorations of what e-Learning is, how it can be used effectively and efficiently, and what role it plays in higher education. The notion of e-Learning continues to resist clear definition and continues to be used interchangeably with "technology." Zemsky and Massy (2004) delineated three broad domains that define e-Learning's principal market niches:

1. e-Learning as distance education
2. e-Learning as facilitated transactions software
3. e-Learning as electronically mediated learning.

Achacoso (2003) said that *technology* tends to be used "as an inclusive phrase to mean any type of equipment or application, inside or outside of the classroom, both computer-based and not, that is used to aid the learning process" (p.3). In addition, any use of the Internet appears to be covered by this most inclusive idiom. For the purpose of this review, e-Learning and *technology* will be used interchangeably to refer to any type of computer-based hardware, software, or product, including the Internet, that is used either inside or outside of the classroom, which aids teaching and/or learning.

Whether technology is going to remain part of the educational landscape appears not to be up for discussion. Technology, it would seem, is here to stay (Thalheimer, 2002; White, 2002). Pittinsky (2003) suggested that the question is not whether e-Learning will take root and mature but rather will this happen suddenly through high-profile initiatives that facilitate change at once or through the "quiet revolution" (p. 10) taking place in more traditional classrooms, which in time may get us to the same point by building on conventions. Thalheimer (2002) claimed that e-Learning is merely following the "product lifecycle trajectory"—euphoria resulting from emergent technologies, followed by failure and then effectiveness (p. 1). Nonetheless, issues related to particular uses, applications, problems, and proliferation warrant further investigation.

e-Learning: The Downside

The problems with e-Learning and the use of technology in higher education have been well-documented. e-Learning has not been the panacea for the ills of higher education that proponents had anticipated. Results of a recent study seemed to capture the reticence currently felt by many in higher education towards e-Learning. Zemsky and Massy (2004), in conjunction with the Thomson Corporation, contended that the e-Learning "boom" has gone "bust." Their study and subsequent report addressed the reasons why e-Learning has failed to attain a strong foothold in higher education. Their fifteen-month study involved six observation posts (weatherstations) on six college campuses. Their research trumped four major e-Learning assumptions that arose largely as a result of the over-optimistic projections of e-Learning's growth[1]. The conclusions drawn by Zemsky and Massy proved somewhat glum:

> Assumption #1: *"If we build it they will come—not so"* (p. iii). The authors contend that, in spite of huge investments in hardware and software, a viable market in e-Learning products has yet to emerge. Only PowerPoint and course management systems (WebCT and BlackBoard) have been widely used. Further, enrollment in online courses came from students already on the six

[1] Moe and Blodget (2002), for example, predicted growth from $9.4 billion in 1999 to $53.3 billion in 2003, representing a Compound Annual Grown Rate in technology of 54 percent from 1999 to 2003. More recent projections by Chen from the Cardinal Advisors of Boston predicted a decrease in the market, with a leveling off at $1.7 billion in 2004 (Thalheimer, 2002).

campuses in their study rather than from the masses at large as had been expected.

Assumption #2: *"The kids will take to e-Learning like ducks to water—not quite"* (p. iii). Students primarily want to be connected to one another, they want to be entertained, and they want to present themselves and their work. "At its best [e-Learning] is viewed as a convenience and at its worst a distraction" (p. iii).

Assumption #3: *"e-Learning will force a change in the way we teach—not by a long shot"* (p. iii). Although faculty may use e-Learning products and devices, most still use traditional teaching methods (lecturing at the front of the class imparting basic knowledge). Hence, the success of PowerPoint and course management systems is to be expected, because these software tools facilitate the distribution of course materials, without challenging teaching methods. The authors conclude that, until faculty change how they teach, e-Learning will continue to struggle to gain a place in higher education.

Assumption #4: *"Electronically mediated learning would lead rapidly to the development of international networks linking both scholars and learners—yes and no" (p. 54).* Many networks do exist that connect scholars and allow lively exchanges of ideas, shared research, and cooperative investigation. International networks for e-Learning, however, have failed to emerge. The authors propose that is due to e-Learning being in its infancy in many countries and that differentiation and specialization of e-Learning technology are largely defined by national cultures and local proclivities above all else.

Zemsky and Massy's study has been hotly contested and loudly refuted. Many have stepped forward in response to their study to offer their own examples of successful implementation and use of technology in higher education (Langenberg, 2004; Stensaas, 2004).

Allen and Seaman (2004), in cooperation with the Sloan Consortium, surveyed officers from a nationwide sample of primary campuses for all postsecondary degree granting institutions active in the United States. The results were said to represent perceptions of the quality and extent of online education in the United States from 2003 to 2004. Among their many findings, they found that administrators considered online experiences the equal of traditional ones:

- Administrators continue to believe that online learning is just as good as face-to-face instruction.

- Administrators of institutions that offer online learning courses believe that their online students are at least as satisfied with their courses as are those in traditional courses.

In spite of the hits that e-Learning has taken of late, it would seem that, at least in some realms, attitudes towards technology-based education continue to be supportive.

When e-Learning doesn't work:

Doubtlessly, the use of technology will fail, on occasion, to accomplish what it was expected to accomplish, but these instances do not merit abandoning technology. Rather, much can be learned from these experiences, as suggested by factors identified in the literature as creating the prospect for e-Learning's failure (Pittinsky, 2003; Zemsky and Massy, 2004; Goodill, 2004):

- overdevelopment of e-Learning products and services based on market speculation
- lack of technical support
- lack of training and development for product users
- lack of adequate financial support
- lack of pedagogical adaptation

Zemsky and Massy (2004) have proposed that products and services were produced in huge quantities based on market projections, creating a glut on the market. Universities acquiring technologies find the choices overwhelming and their product knowledge lacking, and so they make poor decisions, without consideration of products, needs, infrastructure, resources, and goals in their ill-fated attempts at technology adoption (WestEd, 2002).

Once technology-acquisition decisions have been made, issues concerning technical support often arise, because many producers are not well established and ill-equipped to provide adequate support and service to their customers. While the adoption cycle continues to weed out less stable products, services, and providers, in the interim institutions often find themselves with inadequate support from the provider and an in-house staff lacking knowledge of the new technology. As a result, products are shelved or inadequately or superficially implemented.

In addition, end-users of new technology and services often find a lack of support within their organization. Morote (2004) found that this fundamental gap in the technical support network often saps users' motivation to use not only the product in question but other technologies as well. Their initial negative experience grows into general reluctance to use or learn other technologies. Student motivation also is affected when technology fails (Young, 2004). According to Young (2004), students become frustrated when technology use is not seamless because faculty use technology poorly, and these effects are compounded at all user levels when technical support is not immediately forthcoming.

Institutions of higher education that have been forced to make extreme financial cutbacks lose the ability to adequately deploy the technologies in which they have invested. For example, when funding cuts hurt the ability of institutions to provide adequate training and support services, the technologies get shelved or are used only cursorily. Budget cuts also tend to increase the workloads of those who support e-Learning, virtually ensuring that adequate assistance is not readily available. Further, financial restrictions often prevent the development of adequate infrastructure. Without the foresight to match technology with existing infrastructure, or to invest in the expansion of infrastructure as needed to match the technology, attempts to incorporate technologies will be premature. Such efforts will be almost certainly doomed to fail or, at the very least, to fall monumentally short of expectations.

The lack of pedagogical adaptation is one of the more compelling reasons for technology's lack of success (Detweiler, 2004; Zemsky and Massy, 2004). Along with the use of technology in the classroom must come a new approach to teaching. Simply uploading traditional lectures onto BlackBoard does not improve the learning experience. Proponents of e-Learning have argued that e-Learning has the potential to undo the basic production function of higher education, because e-Learning at its best can make education interactive, meaningful, explorative, and durable. If students become engaged in the learning experience through the use of technology, they are less likely to skip classes, fail to ask questions in class, and practice rote memorization merely to get a passing grade on an exam. Pedagogical adaptation to technology in the classroom has the potential to create an authentic learning environment (Siegel, Schmidt, and Cone, 2004; Mayer, Mautone, and Prothero, 2002; Carnevale, 2003).

Young (2004) claimed that, while universities have spent millions of dollars on "smart classrooms" packed with the latest gadgets to assist teaching, Internet ports at every seat, video cameras with motion detectors that can track the lecturer, far less has been spent in time and money in giving professors the skills to use even the simplest technology effectively. As a result, students say technology has actually made some of their professors less effective than they would be if they stayed with traditional methods.

> "Giving professors gadgets without training can do more harm than good in the classroom students say."
>
> *On the other hand…*
>
> "Students also complain, however, when professors make no attempt to use new tools, putting pressure on faculty members to try high-tech tools even if they are not comfortable with them." (Young, 2004)

In order for e-Learning to deliver the kind of success and impact of which it is capable, all of these factors in e-Learning failure must be addressed. The necessity for adequate planning and preparation in order to achieve successful implementation begins at the top. The literature says very clearly that those who make decisions about technology must make provisions for every cog in this network of people and structures that make successful deployment of technology possible. Institutions that fail to consider all of these essential components tend to fail or fall short of their expectations. Institutions that make provisions for each of these elements experience success. Institutions are making huge investments in technology without investing in the human capital it takes to make the innovations successful. This has been the crucial misjudgment that has led to the current atmosphere of discontentment regarding e-Learning's role in higher education.

Prior to a look at the upside of e-Learning, it's useful to review the classic e-Learning debate: is teaching and learning with technology as good as using traditional methods?

Better, Worse, or No Significant Difference?

From the day technology first tentatively entered the realm of higher education, there has been fiery debate over its effectiveness. Three camps have established themselves in the wake of technology's introduction in the higher education classroom:

1. There are the proponents, who cling tenaciously to the claim that technology improves education.
2. There are the opponents, who complain that technology degrades educational quality.
3. There are those in the middle, who maintain there is no significant difference between traditional education and that facilitated with technology (Greenberg, 2004).

In 1992, Thomas L. Russell, as cited in (Greenberg, 2004), set out to find an answer to this classic debate. He sought out comparative studies that showed that technology had a measurable impact on educational outcomes. His work then and since reveals that, for every study that found a measurable benefit, there tends to be a counter study that found no benefit or even a negative impact (Ramage, 2002; Greenberg, 2004). In addition, Russell determined that the majority of research in this field has found no significant difference in learning outcomes (Greenberg, 2004). Nonetheless, comparative studies continue to proliferate.

> "When we accept that…technology *suitably and properly deployed* yields no significant difference for learning outcomes, we can begin to look more rigorously at the ways in which technology *can* provide an edge: as a viable tool for reaching larger populations of students, with the attendant economic, professional, and personal benefits that implies" (Greenberg, 2004, p. 11).

In another recent review of the literature, Welsh (2003) and her fellow researchers demonstrated the validity of Russell's findings, identifying roughly equal numbers of studies in which teaching with technology outperformed traditional teaching methods as there were studies in which traditional teaching outperformed teaching with technology.

Greenberg (2004) suggested that efforts in this direction are largely fruitless and wasteful. Russell (2001) suggested that these researchers are driven by the wrong questions and have the wrong expectations: if researchers would simply accept what Russell calls “the good news”—that technology does not hurt education—then efforts could be shifted to employing technologies properly and effectively. Greenberg (2004) put it this way: “When we accept that, in the final analysis, technology suitably and properly deployed yields no significant difference for learning outcomes, we can stop expecting it to be the be-all, end-all to education” (p. 12).

Can e-Learning and Traditional Education be Equally Successful?

Owen and Aworuwa (2003) provided an analysis of how technology-based education—distributed education, as they call it—stacked up against the traditional classroom. They presented a continuum of instructional delivery modes anchored by traditional “brick-and-mortar-based systems” (p. 22) and fully online instruction, with a concurrent continuum of benefits and tradeoffs for each delivery system. Three findings of their study support the notion that e-Learning and traditional approaches can be complementary:

1. Technology-based instruction, when it is designed to facilitate interaction and timely feedback to students, is as effective as its correspondent classroom instruction in terms of student outcomes.
2. Investments in technology, in terms of fiscal and time expenditures, can have substantial return when trade-offs and relative benefits have been considered and accounted for.

3. Some instructional delivery modes may be better suited for promoting learning at higher cognitive and affective levels than other modes.

Some of these benefits are reported by Irele (1999, as cited in Greenberg, 2004) who, in his overview of the relative effectiveness of distance learning systems, notes the capacity of videoconferencing to quickly reinforce knowledge and correct misunderstandings. Likewise, Siegel and his colleagues (2004) found that using a classroom performance system allows instructors to provide immediate feedback and monitor cognitive and affective factors on a widespread and timely basis, capabilities that have been found to have a significant impact on student outcomes.

Grabe and Grabe (2001) supported the notion that tapping higher-level skills is facilitated by technology. They claimed that, by using asynchronous communication technologies—as in simulation projects, for example—students were more readily able to use the types of skills that foster analysis, evaluation, and synthesis, at the higher levels of Bloom's Taxonomy.

> Traditional instruction has long been criticized for tapping into only the lower levels of Bloom's Taxonomy of the cognitive domain. "With the coming of technology, educators are now able to explore how to teach so that students can achieve at the upper end of the hierarchy" (Owen and Aworuwa, 2003 p. 22-7).

In one of the most striking comparative evaluations of traditional versus non-traditional learning, Joy (2000, as cited in Greenberg, 2004) focused on asynchronous learning networks (ALNs) by randomly selecting several media comparison studies and demonstrating the problems inherent in their methodologies and, subsequently, their conclusions. According to Joy, most researchers fail to control for essential factors such as prior student knowledge, pedagogical methods techniques, and teacher and student abilities. Joy proposed that, rather than compare the effectiveness of varying technologies and instructional media, efforts would be better spent in determining the optimal combinations of instructional strategies and delivery media that would best produce the best learning outcomes for a particular audience (Joy, as cited in Greenberg, 2004). It appears obvious, therefore, that having access to and facility with various instructional methods would provide a great advantage in any instructional modality.

What Makes Success with e-Learning Possible?

Amirian (2003) recently conducted an extensive literature review of print and electronic books and journals, research reports, dissertations, conference proceedings, and Web sites. Areas in the review included educational videoconferencing, distance learning, educational media theory, and technology in learning. Her findings aptly frame the literature on successful use of e-Learning, and will, therefore, be used to guide the discussion on e-Learning success. Six major themes emerged from her extensive analyses:

- Teaching via videoconferencing—and technology in general—is different.
- Interaction is critical.
- Learning goals are primary.
- Pre-planning is essential.
- Faculty need development.
- Students need scaffolding.

Teaching with Technology is Different

The literature suggests that teaching with technology is different from traditional teaching and must be approached differently. According to Amirian (2003), referring specifically to videoconferencing technology and generalizing to other technological media, teaching in this newer medium requires role changes, additional planning, new teaching strategies, and new skills. The literature is clear that "regardless of the technology, good teaching is the basis of using well any technology to teach" (Amirian, 2003, p. 2). Generally, a good classroom teacher will make a good teacher using technology.

The transformation of classroom technology from mere hardware, software, and connections into tools for teaching and learning depends on knowledgeable and enthusiastic instructors who are motivated and prepared to put technology to work on behalf of their students (Rodriguez, 2000). Yet, many teachers do not have the technical knowledge or skills to recognize the potential for technology in teaching and learning. Just knowing how to use a computer is not enough. Instead, teachers must become knowledgeable about technology and self-confident enough to integrate it effectively in the classroom. Faculty, in short, must become "fearless in their use of technology" and empowered by the many opportunities it offers (Rodriguez, 2000). Most instructors want to learn to use educational technology effectively, but they lack the time, access, and support necessary to do so (Zemsky and Massy, 2004; Young, 2004).

Among the recommendations for best practice for teaching with technology, interactivity is paramount.

Interactivity is Critical

One of Amirian's (2003) more important findings is that interactivity is key to success in technology-based learning environments. Interaction, as a teaching strategy, solves many of the "problems" of distance media, promotes critical thinking, and results in higher student satisfaction. In many cases, videoconferencing—and technology use in general—is used in such a way as to imitate television, by bringing experts into our classrooms in many ways, such as presenting the evening news, using observations like closed circuit TV cameras, and watching packaged museum or outdoor science trips like travelogues. Past experience with video media has created the expectation of passivity—sitting in front of a screen and watching. Yet, as a pedagogical strategy, watching is less conducive to learning than watching, presenting, creating, discussing, questioning, and interacting with the teacher, the other learners, and the content. The preferred method, suggested by the review, is to use technology in ways that take advantage of qualities that are inherent to the medium and that might bring new ways of learning to the classroom. Interaction is the key component to supporting a more social learning, negotiating meaning through interaction with peers over distance, and forming a sense of community using the technology (Sexton, 2002; Amirian, 2003; Chou, 2003).

Chou (2003) builds on the literature by delineating four levels of interactions that are key to the successful integration of technology into student-centered learning, building upon a framework suggested by Moore (1989):

- *Learner-Content Interaction:* Characterized as a defining characteristic of education, this type of interaction moves learners to achieve intellectual growth or changes in perspectives.

- *Learner-Instructor Interaction:* Highlighting the importance of the role of the instructor, those teaching with the aid of technology are—in addition to outlining learning objectives, materials, and activities—also responsible for revising their teaching methods and providing evaluation as students progress through the learning process.

- *Learner-Learner Interaction:* The interaction taking place between learners may occur in real-time or delayed time and is not restricted by the presence of the instructor. Collaboration and knowledge sharing are common examples of this type of interaction. Development of student expertise in different subject areas and promotion of community building are encouraged through this type of interaction.

- *Learner-Interface Interaction:* Involving “a process of manipulating tools to accomplish a task” (Hillman, Willis, and Gunawardena, 1994 as cited in Chou, 2004, p. 12), the learner must be empowered with skills for using the technology and feeling comfortable in the learning environment. Good interface design can minimize technological barriers to technology-based learning and enhance interactivity.

Chou proposed that, in order to maximize the positive effects of interaction, addressing these levels should be taken into consideration when technology-based teaching is to be used.

Learning Goals are Primary

A common theme in the literature, according to Amirian (2003), is the pervasive mistake of first choosing technology and then trying to fit it into a learning experience that will have value for students. Amirian said that this approach is backwards. Rather, we should determine our learning goals and then select technologies that support those goals. “Using technology for technology’s sake may not be the best strategy supporting good teaching practices” (p. 3). This sentiment is echoed by Yepes-Baraya (2002, as cited in Peterman, 2003): "Integrated technology is technology that supports and enhances the achievement of specific teaching and learning goals." The learning goals must, therefore, determine the best technology to use.

Pre-Planning is Essential

Not much explanation is necessary in the area of pre-planning—it is at the heart of this issue and has been a pervasive theme in this review. From the time a technology or service is decided upon, planning for implementation must begin. All affected parties must be prepared for integrating the technology, from the on-site technical support staff to the students as recipients. Instructors need adequate training and must develop comfort with the new technology so they can define their learning goals and exploit technology to accomplish them.

Amirian (2003) found that pre-planning appeared to be one of the key pedagogical activities for successful teaching and learning with technology, leading to four pre-planning recommendations:

- Obtain assessments of students' skills with and attitudes toward the technologies being considered, by doing something as simple as creating an introductory activity that gets everyone warmed up.
- Create handouts or other instructional materials to be distributed in advance of the use of a technological innovation.
- Conduct a rehearsal using the presentation materials to make sure all systems are operational and seamless.
- Plan alternatives to guard against the potential problems or failures that are possible with the technologies being used.

The foresight of everyone involved in the deployment of technology is necessary to ease the transition into the use of technology. Long-range planning and collaboration concerning ideas, goals, and uses will streamline the process and help make the success of technological adaptation more likely.

Faculty Need Development

Too often it appears that technology is virtually thrown at teachers with provision of little or no training or support (Zemsky and Massy, 2004), lending little motivation for them to use the technologies. In the literature are many examples of instructors responding in such circumstances by simply transferring their traditional lectures into the new medium, creating a frustrating learning environment for students and an unfulfilling one for themselves.

Amirian (2003) found that, in fact, faculty need ongoing development in order to integrate technologies successfully by adapting teaching methods to technologies they have learned how to use well. She suggested that faculty receive help to do two things: 1) to feel comfortable with the hardware and using the technologies and 2) to create learning opportunities that are designed to take advantage of the capabilities of the technology. Faculty unfamiliar with the technologies they are using are likely to depend on dimensionless transfer of traditional materials to the new technological medium, because they don’t grasp what powerful tools are available to them. Some schools have addressed these needs by taking a team approach, providing technical support and instructional designers. Others simply require that faculty master the technology and design and deliver instruction effectively.

For technology to become a core component of teachers’ instructional repertoires, they require not only familiarity with the equipment or medium but recognition of and skill in exploiting the most productive ways of using it to promote learning. They require time to explore, collaborate with peers, reflect, and engage in hands-on learning. “Experts suggest a 30/70 rule: Spend 30 percent of the technology budget on equipment and 70 percent on the supportive ‘human infrastructure’” (WestEd, 2002).

Some have suggested that there is little intrinsic motivation for many faculty to integrate technology. If so, external motivation in the form of grants, mandates, and a technology component to the tenure process have been suggested in order to mainstream technology in higher education.

Students Need Scaffolding

Much attention of late has been focused on developing methods for facilitating learning in non-traditional environments. Scaffolding is an issue of particular interest and, according to Amirian (2003), is essential for students operating in a technology-based environment. Scaffolding has been used extensively in settings ranging from one-on-one tutoring to traditional classrooms and has been shown able to support divergent learning goals. In spite of limitations of computer-based systems, there have been technological developments that emulate certain facets of the scaffolding process. In most cases, these applications functioned as on-demand help systems and provided the learner with directive and procedural instructions for tasks (Sharma and Hannafin, 2002).

More importantly, instructor-mediated scaffolding is essential when dealing with technology-mediate environments. Amirian (2003) said that students can be helped in scaffolding their technological prowess and their comfort within the technology-based medium. Clearly delineating expectations of work or interactions produced in the technical medium is a powerful facet of scaffolding. She also suggests that skills and comfort levels can be scaffolded by using the technology to explore, to engage in hands-on learning, and to collaborate with peers.

A Best-Practice Model

When technology is deployed well, the results can be extensive and impressive, as evidenced by an example of technology use at its finest, provided by Carol Twigg (2003), director of the Center for Academic Transformation (CAT). The mission of the center at

Rensselaer Polytechnic Institute is to serve as a source of expertise and support for those in higher education who wish to take advantage of the capabilities of instructional technology to transform their academic practices. The center manages a $6-million program called the Pew Grant Program in Course Redesign, whose redesigns have taken place on both small and massive scales. An example of one such redesign for a linear algebra course is instructive.

Total Course Redesign

A linear algebra course at Virginia Polytechnic Institute, originally delivered in 38 small sections, had suffered from inconsistent student academic preparation, inability to accommodate different learning styles, retention problems, and the amnesia and inertia often found in traditional classrooms. Further, there was a substantial lack of uniformity in learning outcomes.

When taught in 38 sections, the course required 10 faculty members, 13 adjunct instructors, and 15 graduate teaching assistants. The redesigned course featured a single 1500-student section created to use a 24/7 computer laboratory with one tenured faculty member and one instructor to manage the course, aided by graduate and undergraduate facilitators to provide students individualized assistance. Two technical staff persons were required to manage the large database at the heart of the course.

With the new format, the instructors could continually improve the course, because when students got stuck on particular problems, instructors knew immediately to pull, correct, or reintegrate the items, adapting their teaching with new features added to an existing body of material. Although the initial workload was heavy, and some faculty complained of the time required for start-up, they appreciated the long-term benefits of the redesign. Many reported finding the new format less mundane than their traditional courses and, once the innovation was off the ground, their workloads more manageable.

The course redesign has also been a financial success. Virginia Polytechnic Institute has reduced spending from approximately $77 per student to $24 per student—a two-thirds reduction. Such cost reductions are not exceptional in CAT's experience. Overall, the courses redesigned for the center's various projects average a savings of about 40%, and collectively, the 30 courses involved in their projects represent a savings of about $3.6 million annually.

Technology According to the Center for Academic Transformation

The center has been able to demonstrate, in the midst of great skepticism, the true potential of technology. Carol Twigg, executive director, has been spreading the word since the center began its work in 1999. Twigg (2000, 2003), noting that a large percentage of total enrollment was concentrated in 25 introductory courses (from 35% to 52% of total enrollment is in those courses), concluded that, in order to have considerable impact on large numbers of students, one should focus on these 25 courses. Making this high-impact list of courses the target of the center's redesigns provided the additional advantage of choosing courses with excellent prospects for technology-enhanced redesign, because they had a more-or-less standardized curriculum, outcomes that could be easily measured, and content over which faculty members were less possessive. That is, there was not a lot of argument about what a course in algebra should look like.

Twigg believes that introductory courses are a prime area where ineffective teaching is found: failure rates are high as they “weed-out” weaker students, resulting in a spike in the number of dropouts between the freshman and sophomore years. So, improvements in these courses should go a long way in improving retention rates. And because introductory courses have a big impact on students’ choices of majors, improving these courses should also increase the likelihood of students staying with some of the more difficult subjects.

In addition, because other disciplines depend on these feeder courses to provide strong foundations for students, faculty and departments who depend heavily on what goes on in them may grow resentful of students in classes for which they are unprepared.

Introductory courses are also quite expensive, despite the common impression that packed lecture halls and low-paid graduate students mean that they are a cost-effective way to deal with large numbers of students. The University of Wisconsin at Madison, for example, spends $1 million per year to teach introductory chemistry. Redesigning such introductory courses would free up considerable resources.

The center has awarded grants of $200,000 to several institutions to redesign large-enrollment introductory courses, including chemistry at the University of Wisconsin at Madison, statistics at the Pennsylvania State University, linear algebra at Virginia Polytechnic Institute, and Spanish at the University of Tennessee.

Twigg sees two related problems with the traditional lecture method.

- Traditional methods treat students as if they all have the same ability level, motivation, learning style, and interest. It is, therefore, difficult to respond individually to students and to most effectively meet their needs.

- Traditional methods are ineffective in engaging students. Classes larger than 30 to 35 might as well be 300 to 3000, because the ability to engage students

> basically disappears. These classes suffer from poor attendance and poor success rates. Students also fail to retain lecture learning.

All of the center's redesigns take advantage of computer-based learning materials such as self-paced interactive tutorials and exercises. More frequent feedback, more repetition, and reinforcement of what the students know and as yet don't know are provided by computerized, low-stakes quizzes. The redesigns promote 24/7 access to learning resources. Further, collaboration and the creation of learning teams are emphasized. New kinds of computer-based materials allow faculty to teach abstract concepts more interactively and to illustrate concepts visually.

Twigg suggests that redesigns will save faculty time and effort as well. All of the redesigns reduce the amount of presentation time. Course management software allow faculty to monitor student performance, including time spent on outside-of-class work. They know if students have been engaged in learning. Much of the grading has been automated. Although some faculty complain about the initial work that is required with a redesigned course, "most agree it is the best experience they have ever had in a classroom" (p. 141). The redesigns relieve the grind of doing the same thing year after year, and the effect tends to be rejuvenating. "The faculty are saying that the quality of their work life has changed immeasurably for the better. They all say that there is a lot of work during the transition, but it is truly worth the effort" (p. 142).

Directions for Further Study

While the literature reveals consensus that technology influences learning, there is little research into how or why this is so. Without further research, it is not possible to make confident decisions regarding the best technologies for reaching certain learning goals. We cannot afford to make the same mistake we have in the past—choosing technology first and then trying to fit ourselves, our pedagogies, and our learning goals. This has led to numerous false-starts and failures. If we can understand which technologies are best for accomplishing which kinds of cognitive or affective goals, then we can make well-informed decisions and increase the probability of deploying technology successfully.

Another area that would benefit from further research concerns how institutes of higher education are collecting and spending their technology fees. It appears from the literature that collecting, allotting, and using technology fees is disjointed and disconnected. If departments and schools are merely given a lump sum budget allocation for technology, then there is no centralized accountability for the vast amounts collected through the fees. How are other institutions controlling, allocating, and directing spending related to technology?

References

Achacoso, M. (2003). *Evaluating Technology and Instruction: Literature Review and Recommendations*. Austin, TX: Division of Instructional Innovation and Assessment, The University of Texas at Austin.

Allen, I. E. and Seaman, J. (2004). *Entering the mainstream: The quality and extent of online education in the United States, 2003 and 2004.* Sloan Center for Online Education. Retrieved December 12, 2004 from the World Wide Web: http://www.sloan-c.org/resources/entering_mainstream.pdf

Amirian, S. (2003). *Pedagogy and Videoconferencing: A review of recent literature.* Presented at the First NJEDge.NET Conference, Plainsboro, NJ, October 31, 2003. Retrieved December 12, 2004 from the World Wide Web: http://www.iclassnotes.com/amirian_handout.pdf#search='NJEDge.NET%20Conference%20%20Amirian' and http://www.iclassnotes.com/amirian_megacon.pdf.

Carnevale, D. (2003). The virtual lab experiment. *The Chronicle of Higher Education: Information Technology*, 49 (21), A30.

Chou, C. (2003). Interactivity and interactive functions in web-based learning systems: a technical framework for designers. British Journal of Educational Technology, 34 (3), pp. 265-279.

Chou, C. C. (2004). A model of learner-centered computer-mediated interaction for collaborative distance learning. *International Journal on E-Learning*, *3*(1), pp. 11-18.

Detweiler, R. (2004). At last, we can replace lectures. *The Chronicle of Higher Education*, Section: The Chronicle Review, 50(44), B8.

Goodill, G. (2004). Where is the learning in e-learning? A critical analysis of the e-learning industry (Operitel Corporation). Peterborough, Ontario, Canada: Operitel Corporation.

Grabe, M., & Grabe, C. (2001). *Integrating technology for meaningful learning.* Boston: Houghton Mifflin.

Greenberg, A. D. (2004). *Navigating the sea of research on videoconferencing-based distance education: A platform for understanding research into technology's effectiveness and value.* Available online: http://www.wainhouse.com/files/papers/wr-navseadistedu.pdf.

Langenberg, D. N. (2004, September 3). Slow progress in e-learning development does not mean no progress at all (Letter to the editor). *The Chronicle of Higher Education*. Available on the World Wide Web: http://chronicle.com/prm/weekly/v51/i02/02b01701.htm.

Mayer, R. E., Mautone, P., & Prothero, W. (2002). Pectoral aids for learning by doing in a multimedia geology simulation game. *Journal of Educational Psychology*, 94 (1), pp. 171-185.

Moe, M. T. and Blodget, H. (2000). *The knowledge web.* Retrieved December 12, 2004 from the World Wide Web: http://www.internettime.com/itimegroup/MOE1.PDF#search='moe%20%20knowledge%20%20web'

Morote, E. (2004). Can an introductory instructional technology course change instructors' perceptions of their technological skills? *Proceedings: Society for Information Technology and Teacher Education Conference,* Dowling College.

Owen, R. & Aworuwa, B. "Return on investment in traditional versus distributed learning," *10th Annual Distance Education Conference, 2003.*

Peterman, L. (2003, April 1). Teacher models of technology integration. *T H E Journal*, 30 (9), pp. 37-38.

Ramage, T. R. (2002) *The "No Significant Difference" phenomenon: A literature review.* Retrieved December 12, 2004 from the World Wide Web: http://www.usq.edu.au/electpub/e-jist/docs/html2002/ramage.html.

Rodriguez, G. (2000). Critical issue: Providing professional development for effective technology use. *North Central Regional Educational Laboratory.* Retrieved December 12, 2004 from the World Wide Web: http://www.ncrel.org/sdrs/areas/issues/methods/technlgy/te1000.htm.

Sexton, C. M. (2002). Interactivity in a distance learning environment: What is it? How do we know we have it? What's the Value Added? The *Turkish Online Journal of Educational Technology.* Retrieved December 10, 2004 from the World Wide Web: http://www.tojet.net/articles/113.htm.

Siegel, J. A., Schmidt, K. J., & Cone, J. (2004). INTICE: Interactive technology to improve the classroom experience. *Proceedings: American Society for Engineering Education,* Washington D. C.: American Society for Engineering Education.

Sharma, P. & Hannafin, M. J. (2002). The evolution of critical thinking and use of scaffolding in a technology-mediated environment. *Proceedings: World Conference on Educational Multimedia, Hypermedia & Telecommunications*, Denver, Colorado.

Stensaas, S. (2004, September 3). Slow progress in e-learning development does not mean no progress at all (Letter to the editor). *The Chronicle of Higher Education*. Available on the World Wide Web: http://chronicle.com/prm/weekly/v51/i02/02b01701.htm.

Thalheimer, W. (2002). Changing e-Learning market is par for the course. *The Journal of New England Technology*. Retrieved November 7, 2004 from The Journal of New England Technology website: http://www.masshightech.com/displayarticledetail.asp?Art_ID=61202.

Twigg, C. (2000). Course readiness criteria: Identifying targets of opportunity for large-scale redesign. *Educause*, May, June.

Twigg, C. (2003). Quality, cost and access: The case for redesign. In M. S. Pittinsky (Ed.), *The wired tower: Perspective on the impact of the Internet on higher education.* Upper Saddle River, NJ: Prentice Hall PTR.

Welsh, E. T., Wanberg, C. R., Brown, K. G. and Simmering, M. J. (2003). E-learning: Emerging uses, empirical results and future directions: International Journal of Training and Development, 7(4), pp. 245-258.

WestEd. (2002). *Investing in technology: The learning return* (Policy Brief). San Francisco, CA: Author.

White, E. (2002). E-Learning forecast. University Business. Retrieved November 15, 2004 from University Business website: http://www.universitybusiness.com/page.cfm?p=43. Summarizes "Charting the Course: E-Learning Providers Respond to Market Conditions" (Newman, A., Chen, E. Y., & Gallagher, S.)

Young, J. R. (2004). When good technology means bad teaching. *The Chronicle of Higher Education*, November 12, 2004. Available online: http://chronicle.com/weekly/v51/i12/12a03101.htm.

Zemsky, R. and Massy, W. F. (2004). Thwarted innovation: What happened to e-Learning and why. Available online: http://www.thelearningalliance.info/Docs/Jun2004/ThwartedInnovation.pdf.