THE FUTURES PROJECT

Higher Education in the Digital Rapids

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THE FUTURES PROJECT: POLICY FOR HIGHER EDUCATION IN A CHANGING WORLD
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> ...digital content and networked applications offer direct opportunities to enhance learning by helping students to comprehend difficult to understand concepts; ...engage in learning; providing students with access to information and resources; and better meeting students' individual needs.[1] (e-Learning)

As some thoughtful observer of higher education noted, universities and colleges are in search of golden ponds, but the world has become whitewater. Higher education is just beginning to feel the impact of a powerful new force–digital technology. Digital technology–the computer, the Internet, as well as the combination of the two–is creating significant change in the nature of teaching and learning.

As we have studied this change as part of the Futures Project: Policy for Higher Education in a Changing World, we have seen a rapid growth in the awareness of academic leaders of the potential power of technology. The use of technology is not an end in itself. Rather it is a tool to enhance teaching and learning–a tool that is sometimes abused (i.e., recent press regarding plagiarism of on-line materials).[3] None the less, it is a tool, however, that allows the process of learning to take place in more effective and compelling ways; in ways that, increasingly, will not be possible to accomplish without the use of technology. As technology continues to improve, and as the ability to use it wisely spreads, the use of the traditional modes of teaching will be less and less practical. The next stage will bring larger gains as we move from a better way of doing what we have always done to rethinking what we are trying to do and how.

Student Reactions[2]

Students Using a Program Called "Mastering Chemistry":

"Although I wasn't too fond of the idea of electronic homework at first, I would have to say it has helped me a great deal in understanding the lesson. Even the areas I would not understand during lecture or discussion, the electronic homework in a way forced me to learn it."

"The electronic homework was essential to my understanding of the concepts reviewed in class."

"The electronic homework really helped me a lot, although it took us very long to do, sometimes had to designate a whole day for it."

Students Using a Program Called "Biology Labs On-Line":

"Virtual Fly and TranslateIT were the assignments I got the most out of. I liked the way it made you systematically think to solve the problems."

"I like the Virtual Fly and EvolveIT activities because they allowed you to do some investigation on your own and they made you think about what was really happening, which made you understand the material better."

"I could experiment and learn by trial and error to prove to myself that the book and what I was working on were in fact the same."

> Just as the earliest movies were filmed versions of stage plays, initial computer-and Internet-based educational offerings generally translated physical-world courses intact into the medium. Videotapes or streaming video substitutes for the lectures, PowerPoint slides took the place of black-board writing and readings were digitized and displayed on-screen. [4]

When the conversation in higher education turns to the subject of technology, there is a tendency to jump, instinctively, to one aspect–the capacity for virtual online education, or education at a distance over the Internet. Virtual education does indeed represent a significant new opportunity.[5] For one thing it is undergoing rapid growth–altogether, there are estimated to be several thousand American institutions providing virtual courses enrolling well over a million students.[6] Enrollments are soaring; hundreds more institutions in other countries now offer such courses; and many more institutions and millions more students are likely to join in this phenomenal growth in the years immediately ahead. Beyond the sheer growth, an emerging body of research makes plain that learning via the Internet can be both effective and satisfying for students.[7] As a result, technology, through the impact on virtual education, has already become a major force in the shift toward greater competition among the providers of higher education and toward the globalization of higher education.[8]

However, as important as the capacity to educate at a distance is, the impact that digital technology is beginning to have on pedagogy, particularly in the traditional classroom is, in the long run, of far greater significance.[9] While the growth of virtual education has been rapid, the change in the traditional classroom is, by comparison, moving more slowly, dependant as it is on acceptance by individual faculty.[10] The change is moving more slowly than virtual education and more slowly than the impact of technology in many fields (such as banking or telecommunications) but still far more rapidly than change typically takes in higher education.[11]

Technology Aids Learning[12]

Professor Patrick Wegner at California State University, Fullerton, developed the Mastering Chemistry (MC) server-based application. MC "focuses on enabling mastering learning by implementing self-paced, individualized and automated assessment covering the content of general chemistry." Each time a student uses MC the data is stored in a database and recalled the next time the student logs in. Automatic reports are generated and sent to the student and instructor. "Students taught using MC performed better than the students using the traditional textbook homework."

"Koedinger and Sueker found that college students using the Practical Algebra Tutor (PAT), an intelligent computer tutor that presents skills 'in the context of authentic, realistic problem-solving tasks,' scored significantly higher in a performance assessment of algebraic problem solving, qualitative reasoning, and the ability to communicate effectively about mathematics than students who did not use PAT."

Much of the early use of the computer and internet in traditional classroom settings served to do ordinary tasks more efficiently-providing the course syllabus and readings, providing a communication link between faculty and students and among students, creating the means for more effective student research.[13] Many faculty are still concerned as to whether the technology is simple and reliable enough to use for more sophisticated learning tasks. Increasingly, however, better and better software is emerging which allows students to take part in more engaging and effective learning that is computer mediated.[14]

Examples of computer mediated simulations from The Biology Labs On-Line Project:[15]

Demography Lab: This lab models human population growth for seven different countries around the globe. It allows students to investigate the effects of population size, age-structure, and age-specific fertility and mortality on population growth. Students can create their own experiments to test for variables such as war, disease, birth-control, and changes in marriage ages.

Evolution Lab: This lab is especially suited for web based interactive simulation because it allows students to use large data sets and understand the importance of time in the evolutionary process. Students can observe the effects of various parameters on the evolution of bird beaks, for example, as well as those parameters that lead to extinction.

Fly Lab: The Fly Lab allows students to design their own fruit flies by varying their phenotype, and then mating them to yield progeny. Analysis of the progeny allows students to understand the rules of inheritance.

Cardio Lab: This lab simulates some of the basic causal effects of various parameters on cardiovascular function, demonstrating concepts such as homeostasis, feedback, and compensation. Students can do experiments on virtual patients with health problems and work with real interventions.

For more information on the Biology Labs On-Line Project, view http://www.biologylab.awlonline.com/

Our estimate is that over the next five or six years, the use of such software will become commonplace, truly transforming the way learning takes place in most settings in traditional classrooms on campus and virtual courses online.[16]

What Gives Technology its Learning Power?

The opportunity ahead lies in the capacity to use digital technology to transform learning in ways that capitalize on what we have known for a longtime about powerful pedagogy-that students learn more, more profoundly, and remember over a far longer period when they are actively engaged in a self-driven learning activity rather than when they are engaged only passively, sitting and listening.[18] Yet a recent study by the Policy Center on the First Year College found that "Extensive lecturing...was the pedagogical technique most often utilized in the classrooms of their students, although only 21.4 percent of students feel that lecturing should be included in their coursework."[19] Digital technology can provide professors with a practical approach to those methods that have been recognized as far more effective than lecturing.[20]

- "69% of Americans believe that the use of computer technology has improved the quality of instruction in their local schools; and
- 82 % believe that schools should invest more in computer technology for instructional purposes."[17] (e-Learning)

Tanya Furman, Associate Professor and Undergraduate Program Head, Department of Geosciences at Pennsylvania State University states, "... I learn so much more from my students when I am not lecturing them, and I am convinced that my students are better prepared to move forward with both their self-motivated learning and their incorporation of technology in their lives."[21]

It is particularly valuable in scientific areas that require laboratory work. For example, an introductory chemistry class of 400 or 500 students requires an exorbitant amount of equipment and staff time; as a result, sophisticated laboratory experience is often not practical. Software now allows students to analyze a sample or change the parameters of an experiment in a virtual way-substantially enriching an otherwise abstract and relatively impersonal class. And because actual laboratory experience is still essential, virtual laboratory time allows more efficient and effective use of real laboratory facilities.

Jeffrey Bell states in his article, The Biology Labs On-Line Project: Producing Educational Simulations That Promote Active Learning, "Eliminating the time constraints of the traditional experiment, the simulations give students the opportunity to design and interpret experiments, to learn from their mistakes, and to revise and redo their experiments just like real scientists."[22]

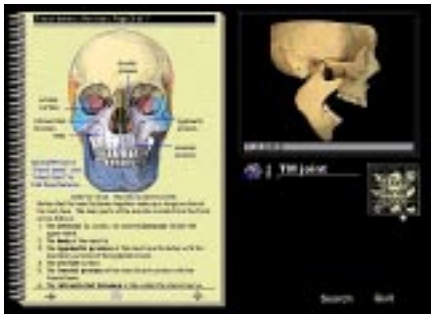
Software also allows virtual experiments that in an actual setting, requires a time span far beyond the practical. John Walkers Solar System Live allows students to view the solar system live or set other times and dates, or to track an asteroid.[23]

Digital Technology Provides Practical Ways to:

Engage students in active learning. New software gives students hands-on experience in essentially any subject.

- Christoph Rose-Petruck, Assistant Professor of Chemistry at Brown University, offers this example: "For instance, the measurement of infrared spectra for the analysis of various solutions is an integral part of educational chemistry laboratories. However, the instruments require a rather detailed technical introduction by the instructor. Typically such instructions are given in the lab in front of the instrument. An alternative is a simulation of the operations of the spectrometer on a web site, allowing students to familiarize themselves with the operation and technological principle before being confronted with the real instrument in the laboratory. They can 'measure' simulated spectra on the web site until they are confident enough to carry out real measurements during the limited time of a laboratory afternoon. This way the instructors' and students' time is used pedagogically more effectively and, most likely, the cost-effectiveness of chemical education can be enhanced."[24]

- Speech pathology students can now manipulate a virtual skull to see how the jaws and tongue move in response to certain muscles.[25]



For a complete demonstration see:
http://www.lib.uiowa.edu/commons/skullvr/background.html

- Similarly a new module for use in teaching about meteorology includes a graphing function so the student can change any variable (for example, a change in ocean temperature) and see the effect. It also provides links connecting to related websites with supplemental graphs and information, and a set of interactive applets allowing the student to study minute by minute changes in geological variables (such as radiation with respect to time of day). We asked one of our interns to try it out. She reported: "As some one who knows absolutely nothing about meteorology or geology, I found these modules were effective... In just half hour's time, I was engrossed in a subject in which I had no previous knowledge."[26]

Connect learning with real life.[27]

- Three archaeologists have created an archaeology workbook and CD-ROM called "Virtual Dig" which is being used in a growing number of programs around the country. "Virtual Dig" helps students conceptualize the entire process of an archaeological dig. Composed of three sections - setup, excavation, and analysis, "Virtual Dig" allows students to set the parameters for their project, ask detailed questions like "how many units will they excavate and where?" and "should the dirt be screened for materials?" as well as determine the logistical aspects of the project such as the budget and housing.[28]

- Professors at the Hofstra School of Law have centered their "Pretrial Litigation" course around an e-mail network. Students communicate with each other and their faculty supervisors as if they are participants in actual litigation. A faculty member serves in a series of roles, first as client, then consultant, judge, reporter and activist, in addition to course leader. Through e-mail, as opposed to traditional memoranda, the course is able to move at a much quicker pace and receives praise from students for its practical experience.[29]

Provide ready, rapid, and interest-generating access to massive amounts of information in ways that encourage students to search, explore and combine information.[30]

- At Virginia Tech, a new CD-ROM tutorial entitled "Woody Plants in North America" teaches students how to identify species of trees according to their scientific classifications. The tutorial includes over 9,500 pictures and full text descriptions of leaves,

twigs, fruit, flowers, bark, form, and range maps for 470 species of woody plants.[31] Students can compare physical appearance, growth rates, etc. of two trees on the screen at the same time. Following study of the tutorial, the student can take a quiz that can be customized to test material that has been covered.

- The Perseus Project, housed at Tufts University, allows users to view Greek and Roman texts, primary and secondary sources, and historical information. Texts are available in Greek, Latin, and English translations with an online dictionary. Users can also find sites mentioned in the text on a map of the Mediterranean and view photographic images and museum collections.[32]

Allow faculty to see, understand, and even exploit the different learning styles each student brings to the classroom. We have always known that students learn differently, but we continue to teach primarily through lecturing, a mode that does not reflect the differences or allow the instructor to understand how students are learning.

- At the University of Colorado's College of Business students "can walk around inside a microcomputer and examine its components," an exercise that appeals to students who learn better when they can see something concrete.[33]

- The Massachusetts Institute of Technology (MIT) created Cybertutor to help students with their math and physics homework. Cybertutor provides an immediate, detailed analysis of a student's performance, including: time spent on each problem, which hints were helpful, and the number of wrong answers that preceded the correct answer. Professors can access a student's profile, compare it to the rest of the class, and adjust future class discussions or provide individual counseling accordingly.[34]

Allow students to easily return to previously covered material (asynchronous learning).[35] In a conventional class, even when discussion is encouraged, students fear that if they try to clear up their own confusion they will delay the whole class. As a result, they often don't ask questions and, as the class progresses, they fall further and further behind.

- At the Virginia Tech Math Emporium, students in beginning math classes can review the course software on the computer seven days a week, twenty-four hours a day. When students are

working in the lab and get stuck, placing their red paper cup on top of the computer brings an instructor to their side to see what help they need.

Force faculty to shift roles from being the source of information to becoming the supervisor or coach of the learning process. In a way, the faculty role comes to resemble Socratic teaching, or the role of the Oxford tutor-reviewing what the student has learned, challenging the student's interpretation, pointing to new materials. But whereas the Oxford system is extraordinarily expensive, technology allows both individual and group attention in a far less costly mode. However, it requires of the faculty not only a greater mastery of content but of learning styles as well.

- Penn State has redesigned its elementary statistics course. One of the most profound impacts of the redesign was refocusing the faculty role from "information presentation to learning facilitation."[36]

- The University of Southern Maine has redesigned its introduction to Psychology courses. The University has increased the number of students in each section and cut the lecture time in half. The time is replaced by interactive Web-based learning activities and individual attention from the professor and from teaching assistants is increased. Those web-based activities include "multiple modules per chapter [that] will allow students to choose modules that match their learning styles, needs and interest." Students can receive instant feedback on their mistakes and rework the modules until they fully understand the concepts being taught.[37]

Another advantage is the ability to provide preliminary experience in a safe setting.[38] The emergence of virtual reality technology offers a training supplement for surgeons who typically require "lengthy and expensive training regimens." The software can be surprisingly realistic, reduce the risk to patients and the need for expensive use of animals in training. It also allows "the trainee to return to the same procedure or tasks several times later as a refresher course."[39]

Any higher education institution could make the improvements in learning that we've outlined, at least in part, without using digital technology. But such improvements usually take so much time and effort by faculty and students that they do not occur.

Critics of Technology

Meanwhile, critics of the use of technology in the classroom often argue that other types of technology have been heralded before–overhead projectors, films, television-none of which have had a major impact. What they don't realize is that none have had the capability to engage the student in active learning, or to gain the other advantages noted above.

Such critics need to realize that the new digital technology simply makes learning much more interesting–even more exciting.[40] Of course, technology is a tool, not an end in itself. It can be used wisely or poorly. It is often over-hyped. But the changes it has brought already are profound. And we need to remind ourselves that the technology in use today is crude and limited compared to what will emerge over the next five years. One need only look at the evolution of computer games to recognize the potential for engaging students. As the inexorable improvement of digital technology continues, and as our understanding of how to deploy it deepens, there will be further gains in capacity, reliability, cost-effectiveness and ease of use.[41] Within a few years it will be impossible, even with great effort, to achieve the same learning results without the use of technology.

Looking Ahead

As higher education moves forward, every post-secondary institution should recognize that digital technology has already begun to change how students learn in every setting (See Appendix A): online courses, elementary and secondary schools, skill training centers, as well as traditional classrooms.[42] Indeed, as the capacity and use of technology continue to advance, the traditional and the online course will look more alike to the student. Each will use technology to enhance learning.[43] Each will encourage active learning and frequent communication with the faculty member and other students.[44] Each will use faculty members as mentors and guides rather than as the source of information. More and more learning will involve both classroom and online instruction.[45]

All those changes will raise important questions that each college should consider. One unexpected benefit is that the debate over technology has moved the goal of improving teaching from a distinctly peripheral position to the center of the university's concerns. This in turn raises the question, what incentives for faculty performance should institutions develop in response to the impact of new technology on pedagogy?

Very soon, those institutions skilled in the use of technology to improve learning will be seen as more dynamic and effective than their less-engaged competitors.[46] Therefore, institutions and faculty that view themselves as excellent at teaching now need to excel at the use of technology if they are to remain leaders. Many faculty will need institutional support as they make this transition.[47]

Finally, students must also be proficient at using digital technology. Every new wave of students arrives at the campus door with greater, but still uneven mastery of technology and with changed expectations.[48] What infrastructure and support should institutions provide students from all backgrounds, with all levels of technical expertise.

In short, as technology's impact on pedagogy becomes more profound, every university and college will need to develop a strategy for its use.[49] Skillful leadership will be needed to help faculty and administrators copy with change and move forward. The faculty reward structure will not change. Higher education is in the digital rapids. And, as any whitewater veteran will tell you, in these circumstances, it is better to steer than drift.

Appendix A

The chart below offers examples of how technology is being used in the classroom via simulations, modules, etc., websites showcasing technology's potential to impact learning, papers offering interesting and unique perspectives on technology and pedagogy, as well campus technology resource centers. The table below is by no means complete and is intended to offer a look at sites we think are using technology positively.

DESCRIPTION	URL
TECHNOLOGY in the CLASSROOM	
Peter Shearman & Roni Linser, World Politics in Transition Simulation	http://ariel.ucs.unimelb.edu.au/~ronilins/WPT/SimHome.html
Mastering Chemistry Learning Server	http://mc.nacs.uci.edu/
Stanford Learning Lab Courselet Project	http://learninglab.stanford.edu/index.cgi
James Walker's Solar System Live	http://www.fourmilab.ch/solar/solar.html
Purdue's Online English Lab: OWL	www.owl.english.purdue.edu/lab
The Math Forum	www.mathforum.com
Forest Biology and Dendrology Educational Sites at Virginia Tech	Http://www.fw.vt.edu/dendro/
Biology Labs Online Preview and Biology Labs Online	www.aw.com/bc/blol and http://www.biologylab.awlonline.com/
ICONS Simulation (the International Communication and Negotiation Simulation	http://www.bsos.umd.edu/icons/
UC-Berkeley's Center for Community Economic Research - The National Budget Simulation	http://garnet.berkeley.edu:3333/budget/budget.html
The University of Iowa: Virtual Hospital Program	http://www.vh.org/Providers/Simulations/PatientSimulations.html
Syracuse University Physics – Gravity Simulation	http://www.phy.syr.edu/research/education/java/SUorbitnew/SUorbitnew2.html
Syracuse University Physics – Twin Paradox, The Light Cone	http://www.phy.syr.edu/courses/modules/LIGHTCONE/java/TwinParadox.html
Syracuse University Physics – The Vector Cross Product	http://www.phy.syr.edu/courses/java-suite/crosspro.html
Syracuse University Physics – Educational Modules and Simulations	http://www.phy.syr.edu/courses/modsim.html
Columbia University's King Lear	http://ccnmtl.columbia.edu/services/showcase/lear.html
Virginia's Uncle Tom's Cabin	http://www.iath.virginia.edu/utc/
BioQuest Curriculum Consortia	http://www.bioquest.org/
Princeton Online Poetry Project	www.princeton.edu/online-poetry/
The George Lucas Educational Foundation	http://glef.org/index.html
UNIVERSITY TECHNOLOGY CENTERS	
Yale Center for Media Initiatives	http://www.yale.edu/cmi
Princeton University: Educational Technologies Center	http://www.princeton.edu/pr/pwb/00/1120/index.shtml
Carnegie Mellon: Center for Innovation in Learning	http://cil.andrew.cmu.edu
Columbia Center for New Media Teaching and Learning	http://ccnmtl.columbia.edu/
PAPERS AND ARTICLES	
Project Kaliedoscope: Papers: How can information technology enhance undergraduate education in science, mathematics, engineering and technology	www.pkal.org/events/car2001/summaries.html
Wake Forest Interactive Multimedia Electronic Journal of Computer-Enhanced Learning and the International Center for Computer Enhanced Learning	www.imej.wfu.edu and http://iccel.wfu.edu
TECHNOLOGY FOR FACULTY TO FACILITATE ON-LINE LEARNING	
Merlot	www.merlot.org
Open Knowledge Initiative	http://web.mit.edu/oki/index.html

Endnotes

[1] "e-Learning," published for the Office of Educational Technology, U.S Department of Education, Washington DC, December 2000: 7.

[2] Ramesh D. Arasasingham, "Enhancing Learning Using Server-Based Tools in General Chemistry," presented at the Change Agents Roundtable: "How Can Information Technology Be Best Used to Enhance Undergraduate SME&T" conference, March 2001, Project Kaleidoscope, 9 March 2001 <http://www.pkal.org/events/car2001/arasasingham.html>; Jeffrey Bell, "The Biology Labs On-Line Project: Producing Educational Simulations That Promote Active Learning," Interactive Multimedia Electronic Journal of Computer-Enhanced Learning, Wake Forest University, October 1999, 21 March 2001 <http://imej.wfu.edu/articles/1999/2/01/printver.asp>.

[3] Digital Plagiarism

There are two sides to the online plagiarism coin–online access has not only increased cases of student plagiarism but also increased the rate at which it is detected. University administrators are starting to realize that not only is Internet plagiarism a serious offense, but it is becomingly increasingly common.

A few examples:

- A company called Turnitin.com has experienced increased popularity as several universities, including Georgetown and Berkeley, have recently signed on to grant access to its services. Turnitin.com scans papers into a database and searches for matches, greatly facilitating plagiarism detection for professors. Turnitin.com and other detection software are making it easier for professors to catch plagiarizers and save their time. Software has also been especially popular with virtual universities. (Young)
- In April 2001 at the University of Virginia, physics professor Louis A. Bloomfield's routine plagiarism check "turned up more than 100 suspicious papers." This prompted Bloomfield to develop his own plagiarism detection software and then make it available for free on the Web. The software has since "been downloaded more than 700 times." (Young)
- "A 1999 study by the Center for Academic Integrity found that 69 percent of professors catch one or more instance of plagiarism each year." (Young)

Jeffrey R. Young, "The Cat-and-Mouse Game of Plagiarism Detection," Chronicle of Higher Education 6 July 2001: A26.

Kevin Werbach, "Clicks and Mortar Meets Cap and Gown: Higher Education Goes Online," Release 1.0 15 Sept. 2000: 6 <www.edventure.com>.

[5] Examples of Virtual Education Opportunities

Virtual courses are expanding access to a variety of educational opportunities. Some of the interesting examples we have found include:

UC Irvine is proposing the first ever graduate on-line degree program in the University of California system. The proposed program in criminology will, hopefully, be offered in the Summer of 2002. The program is looking to enroll 45 graduate students-working professionals in related fields. (Haldane)

Online courses can be used to benefit the parents of college students. Designed by Psychology Professor Barry Leshowitz at Arizona State University, "Student Passages: A Decision Making course for Parents" is an online college course offered to the parents of freshman at the university. "Each week, parents log on to problem-solve a particular issue together...in a classwide chat, then divide into smaller groups to consider the issues further." This course allows parents to learn how to communicate and better solve problems that their children may be facing in college. Leshowitz comments that this course " 'represents a significant innovation in higher education that may serve as a model for building parent communities nationally'" (Auffret).

Norman Borlaug University, a new for-profit virtual university, "is dedicated to providing lifelong learning for the agriculture and food system. Its purpose is to become a global leader in providing, through the Internet, knowledge in the form of courses, learning modules, seminars and other information to businesses and individuals involved in food production, processing, distribution and consumption." The course offerings "are based on collaboration with the leading brick-and-mortar institutions of higher learning, as well as leading-edge thought leaders in the food, business and agriculture communities" including the American Distance Learning Consortium, Cornell University, and others. Earl Ainsworth, CEO of NBU commented, "NBU's core competency lies in making courses Internet-ready to extend the reach of current educational institutions, as well making leading-edge information available in the form of online seminars and problem-solving exercises." (Smith).

Driver safety classes are now being offered online as a viable alternative to state-sponsored traffic school classes. "The online programs available now include a pilot program sponsored by the National Safety Council and three commercial web-based programs. Although anyone with access to the Web can take the programs, they are certified in only a handful of states. The classes use streaming video, lessons and online tests to accomplish what usually takes four to eight hours to do in a classroom." The benefits to these programs include increased convenience, cheaper costs to the student, and greater flexibility with one's schedule (Bannan).

"The U.S. Army has announced that PricewaterhouseCoopers, the consulting company, will lead a $453-million project to deliver distance education to soldiers all over the world." The project, called Army University Access Online, will be lead by a team of 10 companies and 29 colleges. The first courses of the project were offered at three Army bases in January and Army officials estimate "that 15000 students will take courses this year," (Carr, "Army").

The IRS is now offering online courses to its employees via a "consortium of major universities across the country." Arthur D. Little will help the IRS find online programs for its employees. 700 employees will be able to take the first to be offered accounting courses with Florida State University and Florida Community College at Jacksonville. "The IRS plans to enroll about 4,000 employees in other courses (Carlson, "IRS").

The National Center for Education Statistics December 1999 report surveyed two and four year public and private institutions in order to measure the acceptance of new technologies. Key findings include (Lewis):

- In 1997-98, 54% of institutions used two-way interactive video, 58% used asynchronous computer-based learning, 19% used synchronous computer-based instruction.
- Projected plans for the next three years include: start or increase in the use of synchronous computer-based learning (60%), asynchronous computer-based instruction (82%), and CD-ROM (31%).

In 1994, Professor Muriel Harris started the first Online Writing Lab (OWL) at Purdue University. Its goal is to "provide a resource for students who sought writing help but couldn't make it into the physical writing lab." OWL consists of more that 150 electronic "pages" which make handouts and circulars available to the public. As of January 2000, OWL was averaging about 23,789 requests per day and a total of 705,579 requests for the month. OWL has come to be a "complement to classroom instruction, a supplement to face-to-face tutorials, and a stand-alone reference to thousands of writers worldwide," ("About the OWL").

Starting with the class of 2004, Farleigh Dickinson University began their distance learning initiative, requiring students to take at least four online classes over the course of their undergraduate studies. The university plans to extend their course availability over the next few years as well as enhance their technology, train faculty, and identify virtual instructors from around the world. The basis of their initiative is "preparing global citizens who can function and succeed across cultures and environments in an increasingly interdependent world," ("Distance...").

Virtual worlds are being used to "provide support services for distance-education students. A project called BorderLink works with rural high schools along California's border with Mexico to help prepare students for college. Inside the world, nine meeting spaces will let students talk with a guidance counselor, a tutor, or one another," (Young, "Virtual").

Davide Haldane, "UCI Plans 1st Online Degree In UC System," Los Angeles Times 20 July 2001 23 July 2001 <http://www.latimes.com/templates/mi...tstory.jsp?slug+la%2D000059248jul.>;

Sarah Auffret, "Arizona State University course for parents of college students a first," Office of Media Relations and Public Information, Arizona State University, 16 March 2001 <http://www.asu.edu/asunews/Releases/Parents1200.htm>;

Linda H. Smith, "Norman Borlaug Announces Lifelong Learning Company," About NBU: Press Room, Norman Bourlaug University, 20 Sept. 2000, 16 March 2001 <http://www.nbulearn.com/netscape/index.htm>;

Karen J. Bannan, "In Some States, Speeders Cool Their Heels in Online Classes," New York Times 7 Sept. 2000: E12;

Sarah Carr, "Army Picks Consulting Group to Run Distance-Education Effort," Chronicle of Higher Education Online 5 Jan. 2001, 15 Feb. 2001 <http://chronicle.com/weekly/v47/i17/17a04601.htm>;

Scott Carlson, "IRS Will Begin Taking Online Courses," Chronicle of Higher Education Online 1 June 2001, 25 June 2001 <http://chronicle.com/weekly/V47/i38/3803003.htm>;

Laurie Lewis, et al., "Distance Education at Postsecondary Education Institutions: 1997-98," published for the National Center for Education Statistics, NCES #2000-013, U.S. Department of Education, Washington, DC. Dec. 1999, 9 April 2001 <http://nces.ed.gov/pubs2000/2000013.pdf>;

"About the OWL: The History of our OWL," Online Writing Lab, Purdue University, 26 Feb. 2001 <http://owl.english.purdue.edu/lab/history.html >;

"Distance Learning Initiative," Distance Learning at Farleigh Dickinson University, Farleigh Dickinson University, 21 March 2001 <http://inside.fdu.edu/pt/dli.html>;

Jeffrey R. Young, "Virtual Reality on a Desktop Hailed as New Tool in Distance Education," Chronicle of Higher Education 6 Oct. 2000: A43.

[6] The Futures Project: Policy for Higher Education in a Changing World created a database of institutions offering virtual courses. As of February 2001, there were almost 1,200 institutions listed in the database. After February 2001, we discontinued the database because other reliable estimates were appearing. See the Futures Project: Policy for Higher Education in a Changing World, "Report on Database of Institutions Offering Virtual Courses," Feb. 2001 <www.futuresproject.org>.

"There were an estimated 753,640 formal enrollments in distance education courses at 2-year and 4-year higher education institutions in the 1994-95 academic year. By 1997-98, (this number) had grown to 1,632,350. Enrollments may include duplicated counts of students, since institutions were instructed to count a student enrolled in multiple courses for each course in which he or she was enrolled" (Laurie Lewis, et al., "Distance Education at Postsecondary Education Institutions: 1997-98," published for the National Center for Education Statistics, NCES #2000-013, U.S. Department of Education, Washington, DC. Dec. 1999, 9 April 2001 <http://nces.ed.gov/pubs2000/2000013.pdf>).
For a more detailed look at the enrollment growth in virtual education, enrollment growth in distance education courses, as well as examples of for-profit

arms of non-profit institutions, see Frank Newman and Lara Couturier, "The New Competitive Arena: Market Forces Invade the Academy," 26 Jan. 2001, 23 Feb. 2001 <www.futuresproject.org>.

[7] Learning Online can be Both Effective and Satisfying

The Futures Project reviewed the research that is available on the effectiveness of virtual learning. Because online education is relatively new, there is not a great deal of published research. However, we found several good studies that make plain that virtual education can be both effective and satisfying.

Sivin-Kachala and Bialo reviewed a number of research studies on the impact of technology in education. In one example, they reported that Ruberg found that "more than half of the students described as 'seldom' participating in face-to-face class discussions participated online at about the same rate as students described as 'frequent' participants in face-to-face discussions. As a group, the 'seldom' participants contributed an average of more than two messages per student per networked-based discussion," (Sivin-Kachala and Bialo).

Atkinson College analyzed student grades in fourteen courses that were offered in at least two instructional modes: Internet-based, correspondence, and in-class. The College found that the mean grade for Internet-based courses, 5.88, was significantly higher than that for in-class instruction, 5.60, which was significantly higher than the mean for correspondence courses, 5.39 (Wideman and Owston).

In the fall of 1996, California State University, Northridge, taught Social Statistics in a virtual and traditional classroom setting. The students in the virtual class scored an average of 20% higher than those in the traditional class. In addition, the virtual class had "significantly higher perceived peer contact, and time spent on class work, a perception of more flexibility, understanding of the material and greater affect toward math, at semester end, than did the traditional class," (Shutte).

Online sections of courses and Internet discussions have been found to help make students more comfortable in discussing personal health issues like emotional disorders, alcohol and drug abuse, and sexuality. "Almost without exception, the students seemed to be more at ease with discussing these issues online than in a regular classroom." In addition, Jennifer Lieberman, the "assistant director of online instructor development at Online-Learning.net, a company hired by the University of California at Los Angeles and others to market and deliver online courses, adds that she has seen a similar phenomenon occur in online biology and anthropology courses," (Carr, "Students").

Jay Sivin-Kachala and Ellen R. Bialo, "The 2000 Research Report on the Effectiveness of Technology in Schools, 7th Edition," Software Information Industry Association, (2000): 110;

Herbert Wideman and Ronald D. Owston, "Internet-based Courses at Atkinson College: An Initial Assessment," published for the Centre for the Study of Computers in Education (1999), York University, 4 June 2000 <http://www.edu.yorku.ca/csce/tech99-1.html>;

Jerald G. Schutte, "Virtual Teaching in Higher Education: The New Intellectual Superhighway or Just Another Traffic Jam?" published for the Sociology Department, California State University, Northridge, 31 Mar. 2000 <http://www.csun.edu/sociology/virexp.htm >;

Sarah Carr, "Students Appear More Willing to Discuss Personal-Health Issues Online," Chronicle of Higher Education 13 Oct. 2000: A6.

[8] For a thorough analysis of the growing competition among providers of higher education, see Frank Newman and Lara Couturier, "The New Competitive Arena: Market Forces Invade the Academy," 26 Jan. 2001, 23 Feb. 2001 <www.futuresproject.org>.

[9] Chris Dede compiled, from a series of other research studies, a list of unique ways technology can enhance learning. This list is quoted directly from, "The Potential of Emerging Learning Technologies for Undergraduate SMET Education."

"Sophisticated computers and telecommunications have unique capabilities for enhancing learning (Dede, 2000). These include:

- centering the curriculum on 'authentic' problems parallel to those adults face in real-world settings (Cognition and Technology Group at Vanderbilt, 1997)
- involving students in virtual communities-of-practice, using advanced tools similar to those in today's high-tech workplaces (Linn, 1997)
- facilitating guided, reflective inquiry through extended projects that inculcate sophisticated concepts and skills and generate complex products (Schank, Fano, Bell, & Jona, 1994)
- utilizing modeling and visualization as powerful means of bridging between experience and abstraction (Gordin & Pea, 1995)
  enhancing students' collaborative construction of meaning via different perspectives on shared experiences (Chan, Burtis, & Bereiter, 1997)
- including pupils as partners in developing learning experiences and generating knowledge (Scardamalia & Bereiter, 1994)
- fostering success for all students through special measures to aid the disabled and the disenfranchised (Behrmann, 1998)"

Chris Dede, "The Potential of Emerging Learning Technologies for Undergraduate SMET Education," presented at the Change Agents Roundtable: "How Can Information Technology Be Best Used to Enhance Undergraduate SME&T" conference, March 2001, Project Kaleidoscope, 14 March 2001 <http://www.pkal.org/events/car2001/dede.html>.

[10] Although faculty have access to technology, they are often uncomfortable with it in comparison to students because they "must adapt not only to the technology, but also to a new form of pedagogy," which changes their role from "conveyors of information" to coaches for their students (Michael A. Baer, from a speech delivered at the Compaq CIO forum, 27 Sept. 2000, American Council on Education).

[11] The Boston Consulting group describes the Internet's ability to enhance communications: "the Internet for the first time transcends the tradeoff between reach and richness in the interaction between organizations and individuals. Historically, when companies wanted to communicate with a mass audience they had to provide very limited content in the message-the typical thirty second television commercial. When, instead, companies needed a rich interaction that conveyed much information and was responsive to the unique needs and concerns of individuals, they had to use a forum with very limited reach-the salesman in a car dealership. The Internet has broken through this frontier by allowing companies to interact with millions of people and yet provide vast amounts of customized information to each one" (David Collis, "'When Industries Change, Revisited': New Scenarios for Higher Education," Forum for the Future of Higher Education, Yale University, New Haven, Sept. 1999: 4).

[12] Ramesh D. Arasasingham, "Enhancing Learning Using Server-Based Tools in General Chemistry," presented at the Change Agents Roundtable: "How Can Information Technology Be Best Used to Enhance Undergraduate SME&T" conference, March 2001, Project Kaleidoscope, 9 March 2001 <http://www.pkal.org/events/car2001/arasasingham.html>;

Jay Sivin-Kachala and Ellen R. Bialo, "The 2000 Research Report on the Effectiveness of Technology in Schools, 7th Edition," published for the Software Information Industry Association (2000): 25.

[13] "Pupils act as partners in developing learning experiences and generating knowledge. Through interactions both inside the classroom and with distant archives and experts, their collaborative construction of meaning is enhanced via different perspectives on shared experiences," (Chris Dede, "The Potential of Emerging Learning Technologies for Undergraduate SMET Education," presented at the Change Agents Roundtable: "How Can Information Technology Be Best Used to Enhance Undergraduate SME&T" conference, March 2001, Project Kaleidoscope, 14 March 2001 <http://www.pkal.org/events/car2001/dede.html>).

[14] Jeffrey Bell, "The Biology Labs On-Line Project: Producing Educational Simulations That Promote Active Learning," Interactive Multimedia Electronic Journal of Computer-Enhanced Learning, Wake Forest University. October 1999, 21 March 2001 <http://imej.wfu.edu/articles/1999/2/01/printver.asp>.

[15] "Consortiums of academic experts, educational technologies, and businesses will work to develop, update, refine, and improve these courses. As a society, we will be able to realize tremendous efficiencies by developing these top-quality courses once, rather than having every teacher in the country repeatedly doing lesson planning for the same courses" (Roger Shank and Kemi Jona, "Extracurriculars as the Curriculum: A Vision of Education for the 21st Century," presented at the "Forum on Technology in Education: Envisioning the Future," Conference, United States Department of Education, Washington DC, December 1-2, 1999, 21 March 2001 <http://www.air-dc.org/forum/Schank.pdf>).

[16] "e-Learning," published for the Office of Educational Technology, U.S Department of Education, Washington DC, December 2000: 9.

[17] The Impact of Technology on Learning: A Survey of Research

K-12:
The Bertelsmann Foundation evaluated learner outcomes after applying media and technology to education at the Athens Academy in Georgia. Key findings include 92% of mathematics students said that learning was as or more exciting, and students who used computers in Middle School Language Arts "significantly outperformed similar groups on a standardized national writing examination" ("The Potential").

"Compared to first graders who received only traditional instruction, students who used the technology-based literacy system regularly over a period of three months demonstrated significantly greater gains in basic language skills, such as understanding the relationships among the parts of the English language, classification, and reading comprehension" (Sivin-Kachala 7).

Sivin-Kachala and Bialo reviewed a number of research studies on the impact of technology in education. One of these studies examined low-achieving ninth grade students. He found that "they demonstrated significantly greater gains in both mathematics and reading skills than another group of low-performing students who received traditional instruction without access to computers. Both groups had the same amount of total instruction time" (Sivin-Kachala 20).

Researchers at the Center for Special Applied Technology examine fourth and sixth grade students covering a unit on civil rights. "Students who had online access learned more in the Civil Rights Unit than students who did not go online...Their final projects were rated as stronger overall, and stronger in most of the specific competencies measured" (Sivin-Kachala 33).

An analysis of the Basic Skills/Computer Education program in West Virginia found that the program produced significant gains in scores on the Stanford-9

achievement test, and that the program had especially positive outcomes for girls, low-income and rural students (Mann).

"'The Role of Online Communications in Schools: A National Study' demonstrates that students with online access perform better. The results show significantly higher scores on measurements of information management, communication, and presentation of ideas for experimental groups with online access than for control groups with no online access. It offers evidence that using Scholastic Network and the Internet can help students become independent, critical thinkers, able to find information, organize and evaluate it, and then effectively express their new knowledge and ideas in compelling ways" ("The Role").

Post-Secondary:

In 1990, researchers found that communicating electronically encouraged apprehensive writers to take more risks, resulting in more equal patterns of participation within a group (Mabrito).

In a 1997 Kansas State University survey of students who completed web-based courses during the 1996-97 year researchers found ("Student Survey"):

- 62% of respondents strongly agreed that the instructor used the technology effectively to engage the students.
- 50% of respondents strongly agreed that their interest in the course subject increased as a result of taking the web-based course.
- 50% of respondents strongly agreed that web-based learning was well suited to the way they learned.
- Most students, 62%, became comfortable with the technology used in class within the first week. Additionally, 29% felt comfortable within the first month of the course.

In 1998, Florida International University began to utilize multimedia classrooms to teach freshman composition classes. The classes would view videos, brainstorm essay ideas within groups, prepare assignments, and critique each other's work. Key findings include (Stinson):

- Attendance was consistently higher in the multimedia classroom, 98% compared to between 85% and 90%.
- In the multimedia classroom there were no dropouts compared to rates averaging just over 10% in the traditional classroom.

In a study comparing the performance of students taught chemistry in a traditional classroom setting versus those taught using the server-based application "Mastering Chemistry," it was found that "students taught using MC performed better than the students using the traditional textbook homework" (Arasasingham).

At the Texas Tech University, the aim of the Introductory Psychology course redesign project was threefold: behavioral, encouraging interaction with the web materials on a regular basis; societal, improving access universally to course materials on the web; and cognitive, "engaging students in active learning with hands-on lab exercises and quizzes delivered on the web." Evaluations showed that "students in the web-based version of the course learn somewhat more than do students in the lecture versions," (Maki).

"The Potential of Media Across the Curriculum: A Summary of Findings from the 1996-97 Evaluation at Athens Academy," published for the Bertelsmann Foundation, Guetersloh, 1997;

Jay Sivin-Kachala and Ellen R. Bialo, "The 2000 Research Report on the Effectiveness of Technology in Schools, 7th Edition," published for the Software Information Industry Association (2000);

Dale Mann, Charol Shakeshaft, Jonathan Becker, Robert Kottkamp, "West Virginia Story: Achievement Gains from a Statewide Comprehensive Instructional Technology Program," Milken Exchange 10 Mar. 1999 <http://www.mff.org/edtech/article.taf?_function=detail&Content_uid1=127>;

"The Role of Online Communications in Schools: A National Study," CAST, 4 Oct. 2000 <http://www.cast.org/publications/stsstudy>;

Mark Mabrito, "Local Versus Global Computer Conferences: Case Studies of Apprehensive Writers," presented at the Teaching in Community Colleges Online Conference, University of Hawaii, Honolulu, April 7-9, 1998. 2 Mar. 01. <http://leahi.kcc.hawaii.edu/org/tcon98/paper/>;

"Student Survey of Courses Using the WWW: Summary of Results," Kansas State University Office of the Provost, Kansas State University, Manhattan, 1997, June 2000 <http://www.ksu.edu/provost/appxii.htm>;

Beth MacNeil Stinson and Kenneth Claus, "The Effects of Electronic Classrooms on Learning English Composition: A Middle Ground Between Traditional Instruction and Computer Based Instruction," THE Journal 27.7, Feb. 2000: 98-102;

Ramesh D. Arasasingham, "Enhancing Learning Using Server-Based Tools in General Chemistry," presented at the Change Agents Roundtable: "How Can Information Technology Be Best Used to Enhance Undergraduate SME&T" conference, March 2001, Project Kaleidoscope, 9 March 2001 <http://www.pkal.org/events/car2001/arasasingham.html>;

William S. Maki, "Five Years of 'Learning without Lectures': An Updated Case Study of Distributed Learning," presented at the Change Agents Roundtable: "How Can Information Technology Be Best Used to Enhance Undergraduate SME&T" conference, March 2001, Project Kaleidoscope, 8 March 2001 <http://www.pkal.org/events/car2001/maki.html>.

Taken directly from, "E-Learning, Putting A World - Class Education at the Fingertips of all Children."

SELECTED EXAMPLES OF RESEARCH ON THE EFFECTIVENESS OF EDUCATIONAL TECHNOLOGY

YEAR	STUDY	PURPOSE	FINDINGS
2000	*Evaluation of the Use of Technology in Illinois Public Schools:Final Report* by Silverstein, Frechtling, and Miyaoka[37]	To determine the nature, extent, and effectiveness of the application of technology for improving education in Illinois.	Controlling for a school's poverty level, technology use has a small but significant impact on student achievement as measured by the Illinois testing program. The impact is generally strongest at higher grade levels.
2000	*Miami Dade County Public Schools Assessment Study: 1999-2000* by the Milken Family Foundation, Florida Educational Technology Corporation (FETC) and North Central Regional Educational Laboratory (NCREL)[38]	To recognize and ensure that the students of the Miami-Dade County Public Schools have the technology education they need to succeed in the digital age.	Innovative programs are found to be enhancing student learning through technology. Therefore, it is recommended that the school administration take actions necessary to extend the benefits of technology use to all students.
1999	*Computer-Assisted Cooperative Learning in Integrated Classrooms for Students With and Without Disabilities* by Xin[39]	To determine the effects of computer assisted cooperative learning in classrooms for students with and without disabilities.	Students with and without disabilities achieved significantly higher scores through participation in computer assisted cooperative-learning groups than students who participated in whole-class learning.
1999	*The Idaho Technology Initiative: An Accountability Report to the Idaho Legislature on the Effects of Monies Spent through the Idaho Council for Technology in Learning* by The State Division of Vocational Education, The State Department of Education, Bureau of Technology Services[40]	To evaluate the impact of Idaho's investment in technology for learning.	The benefits of technology in teaching and learning included: increased academic achievement, improved technology literacy, increased communcation, innovative teaching, positive relationships with the community, more efficient operation of schools, and technically qualified students ready to enter the workforce.
1999	*West Virginia Story: Achievement and Gains from a Statewide Comprehensive Instructional Technology Program* by Mann, Shakeshaft, Becker, and Kottkamp[41]	To investigate the effectiveness of the Basic Skills/Computer Education (BS/CE) program in West Virginia.	Students participating in the BS/CE program achieved significant gains in reading, writing and math. Specifically, the program was found to account for 11 percent of students' improvements on the Stanford-9 from 1996-98. BS/CE was also found to be more cost-effective than other interventions and was especially successful with low-income and rural students as well as with girls.
1998	*Does it compute? The Relationship Between Educational Technoloy and Student Achievement in Mathematics* by the Educational Testing Service[42]	To examine if technology increases achievement and if the methods in which it is used affects achievement.	Technology use by students was positively related to academic achievement, especially when used to teach higher-order thinking skills. Among other findings: for eighth-graders, the use of technology to teach higher-order thinking skills was related to a .42 gain of a grade level in academic achievement in mathematics, while using computers for learning games was related to a .15 gain.

YEAR	STUDY	PURPOSE	FINDINGS
1998	*Project TELL Telecommunications for Learning: Report of a Seven-Year Study to Bell Atlantic* by Birenbaum and Kornblum[43]	To determine if under-achievement count be reversed through home access to computers and telecommunication networks.	Gains in motivation and performance were correlated to the time students spent on computer-based telecommuncations environments in reading and math.
1998	*Rhode Island Teachers and Technology Initiative: Findings from the Pilot Year* by Henriquez and Riconscenta[44]	To determine if providing training and laptop computers for teachers will contribute to school reform in the area of technology use.	Teachers who participated in the program noted positive changes in student abilities and work habits. Substantial changes to teachers' professional practices due to the program were also found, including teachers becoming more reflective about their teaching practices, spending more time advising their students, and spending more time working with other teachers on curricular and instructional planning.
1998	*The Effect of Hypermedia Authoring on Elementary School Students' Creative Thinking* by Liu[45]	To investigate the impact of hypermedia authoring on scores of creativity.	Engaging in hypermedia authoring resulted in significant gains for students on examinations measuring creativity.
1998	*The Union City Story: Education Reform and Technology - Students' Performance on Standardized Tests* by Chang, Henriquez, Honey, Light, Moeller and Ross[46]	To explore the difference in performance between students who have access to technology at home versus students who only have access to technology at school.	More access to technology does make a difference in student performance in writing, however, performance in math could not be contributed to greater access to technology.
1998	*Using the Internet to Enhance Student Understanding of Science: The Knowledge Integration Environment* by Linn, Bell and Hsi[47]	To determine whether Knowledge Integration Environment software programs helps increase students understanding of science and their ability to solve relevant problems.	The software allows students to interpret and apply significantly more complex pieces of information and was found to be motivating and exciting to students. In short, it contributed to students' understanding of science.
1997	*Word Processors and Children's Writing in a High-Computer-Access Setting* by Owston and Wideman[48]	To determine if a high-computer access environment and regular, sustained use of word processing software improved writing quality.	Students in high-computer-access schools made greater improvements in writing quality over the course of the study than did students who were in low-computer-access schools.
1996	*The Role of Online Communication in Schools: A National Study* by the Center for Applied Special Technology[49]	To investigate the effects of online communications on student achievement and attitudes.	Online access can help students become more independent, critical thinkers, able to find information, organize it and evaluate it, and then effectively express their new knowledge and ideas in compelling ways.

"e-Learning," published for the Office of Educational Technology, U.S Department of Education, Washington DC, December 2000: 22-23.

[18] Linda J. Sax, Shannon K. Gilmartin, Jennifer R. Keup, Frank A. DiCrisi III, and Alyssa N. Bryant, Designing an Assessment of the First College Year: Results from the 1999-2000 YFCY Pilot Study (A Report for the Policy Center on the First Year of College, Brevard College, Prepared by the Higher Education Research Institute, Graduate School of Education & Information Studies, University of California, Los Angeles, Oct. 2000) 23 Feb. 2001: 30 <www.gseis.ucla.edu/heri/yfcy/yfcy_report.pdf>.

[19] "Results from the Questionnaire for User Interaction Satisfaction showed that in general, students have rated their learning experiences in the electronic classrooms consistently higher than their learning experiences in traditional classrooms. Students reported that they learned more, the class was more interesting, and that they were more motivated. They also thought they had a greater opportunity to be heard by the instructor and that they heard more from their classmates" (Ben Schneiderman, et al., "Emergent Patterns of Teaching/Learning in Electronic Classrooms," Educational Technology Research & Development 46.4 (1998): 23-42).

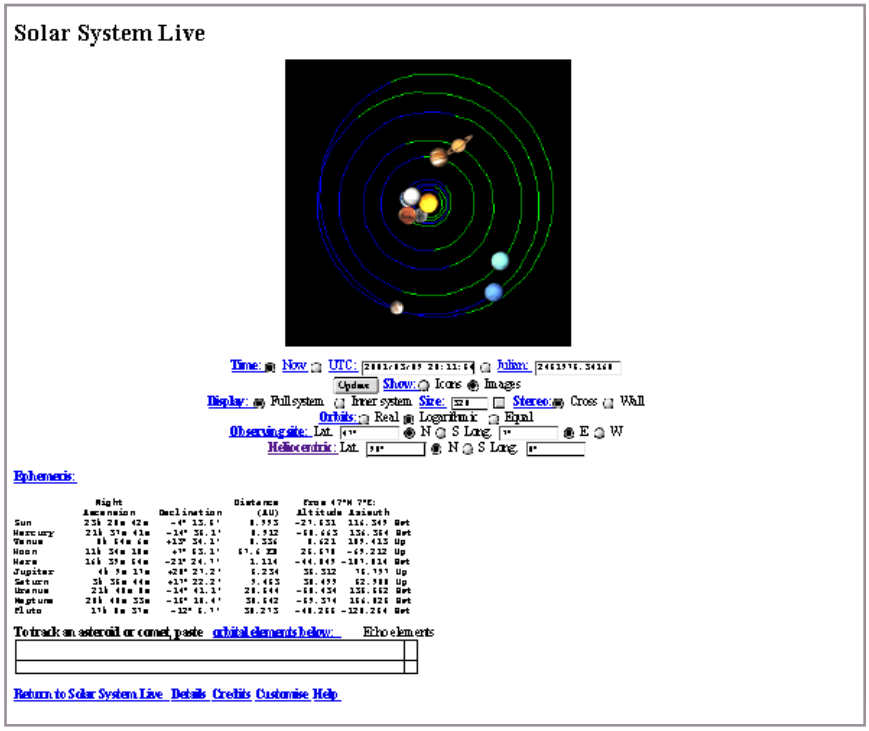
Technology Available to Faculty to Facilitate Online Learning

Faculty Aids	Description	Link
Merlot	A web-based resource with links to online teaching materials, sample assignments, and a peer review system.	http://www.merlot.org
Open Knowledge Initiative	A free web-based course-management system compiled by Massachusettes Institute of Technology and Stanford University, providing access to web-tools such as gradebooks, portfolios, and web-based testing programs.	http://web.mit.edu/oki/index.html

[20] Tanya Furman, "How can information technology enhance undergraduate SME&T?" presented at the Change Agents Roundtable: "How Can Information Technology Be Best Used to Enhance Undergraduate SME&T" conference, March 2001, Project Kaleidoscope 9 March 2001 <http://www.pkal.org/events/car2001/arasasingham.html>.

[21] Jeffrey Bell does not see simulations as a replacement for "wet labs" but rather an avenue to allow students to increase their lab experience for those experiments that cannot normally be done or done well enough in a traditional lab setting. (Jeffrey Bell, "The Biology Labs On-Line Project: Producing Educational Simulations That Promote Active Learning," Interactive Multimedia Electronic Journal of Computer-Enhanced Learning, Wake Forest University October 1999, 21 March 2001 <http://imej.wfu.edu/articles/1999/2/01/printver.asp>).

[22] John Walker's Solar System Live offers students an opportunity to view the solar system live or set the time date, etc., as well as track an asteroid.
To view: http://www.fourmilab.ch/solar/solar.html



Solar System Live, ed. John Walker, March 1995, Fourmilab, Switzerland, 14 March 2001 <http://www.fourmilab.ch/solar/>.

[23] Christoph Rose-Petruck, "Re: Virtual Example," E-mail to Lara K. Couturier, 2 Mar. 2001.

[24] "The Bones of the Skull," Information Commons, Background Information, Hardin Library, University of Iowa Libraries, 2 Nov. 2000 <http://www.lib.uiowa.edu/commons/skullvr/background.html>.

[25] Miranda R. Chen, Memo to Jamie E. Scurry, The Futures Project, Providence, RI. 27 Oct. 2000.

[26] In 1996, the University of Cincinnati began Teaching Human Rights On-Line (THRO). THRO uses case methods and simulations to force students to evaluate choices "confronting a judge, administrative official, or business executive struggling to balance ethical claims against legal, political, and economic values" (Howard Tolley, "Teaching Human Rights On-Line: Cases for Critical Thinking and Cross Cultural Communication," Prepared for delivery at the Annual Meeting of the International Studies Association, March 17-21, 1998 in Minneapolis, Minnesota, University of Cincinatti, June 2000 <http://www.oz.uc.edu/~tolleyhb/papers/marseille.html >).

[27] David Monarchi, "New 'Virtual Dig' Lets Archaeology Students Keep Hands Clean," published for News and Communication Services, Oregon State University, Feb. 2000, 10 Apr. 2000 <http://osu.orst.edu/dept/ncs/newsarch/2000/Feb00/virtudig.htm>.

[28] Andrew Scheppard and Eric Freedman, "A Pretrial Litigation Course with Technology," Technology Tools for Today's Campuses, ed. James Morrison, July 1997, project for Horizon site, 13 June 2000 <http://horizon.unc.edu/projects/monograph/CD/Social_Sciences/Scheppard.asp>.

[29] The BioQUEST Library of Beloit College is an example of a consortium of resources regarding biology that is accessible to anyone in any place. BioQUEST is an annual peer-reviewed publication of computer-based curricular materials that compiles more than "60 software simulations, tools, data sets, and other supporting materials" in all fields of biology. The modules in the BioQUEST library cover a huge variety of topics from the effects of acid rain to protein structures. They have been designed to provide a flexible problem-solving space for investigations that have varying levels of difficulty. The reasoning behind the BioQUEST consortium is that students learn best when given the opportunity to think through and solve problems like scientists do. The collection has been compiled through extensive review, testing, and actual classroom use (John R. Jungck, ed., "The BioQUEST Libray," Bioquest Curriculum Consortium Oct. 2000 <http://www.bioquest.org >).

Examples of e-Libraries Providing Direct and Indirect Access to Information

e-Library	Description	Link
ebrary Inc.	Enables the free and unrestricted viewing of copyrighted materials on the Internet and the ability to print those materials at photocopy-equivalent costs.	http://www.ebrary.com
netLibrary Inc.	Offers more than 30,000 digitized books from various different publishers to public, academic, and corporate libraries to allow their patrons faster, easier access to information.	http://www.netlibrary.com
Questia Media Inc.	Subscription based online library offering access to over 35,000 titles as well as research and writing aids.	http://www.questia.com/index.jsp

[30] John Seiler, John Peterson, Jeffrey Smith, and James Ward, "Welcome to the Forest Biology and Dendrology Educational Sites at Virginia Tech," Virginia Tech, Oct. 2000 <http://www.fw.vt.edu/dendro/>.

[31] The Perseus Project, ed. Gregory Crane, Aug. 2000 <http://www.perseus.tufts.edu/ >.

[32] Jeffrey R. Young, "Class in a 3-D Lecture Hall," New York Times on the Web 9 Nov. 2000, 10 Nov. 2000 <http://www.nytimes.com/2000/11/09/technology/093DDD.html>.

[33] Arthur B. Ellis, Workshop on Improving Undergraduate Education in the Mathematical and Physical Sciences through the Use of Technology, Preliminary Report of the National Science Foundation's Tech Ed 99 Workshop, National Science Foundation, Arlington, VA, 1 Sept. 1999, 26 Jan. 2001 <http://www.wcer.wisc.edu/teched99/NSFWkshpPRELIM.pdf >.

[34] The School of Computer Applications at Dublin City University (DCU) established virtual courses and an Internet-based tutorial system that allows students to view and practice lecture material online. The system also allows students to pause a lecture and practice the material in the tutorial section. Students can review passages of lectures that they didn't understand or they can explore a topic in depth by browsing related material, (Claus Pahl, "Delivery of a Virtual Integrated and Interactive Undergraduate Course," published for the School of Computer Applications, Dublin City University, Dublin 9: 1-3 <http://hazelwood.itsligo.ie/staff/bmulligan/web/Education%20Technology/EdTech2000/session1a/pahl.pdf>).

[35] "The Pew Grant Program in Course Redesign. Round 1 Grant Awards. Penn State University. Course Title: Elementary Statistics," Center for Academic Transformation, Rensselaer Polytechnic Institute, Troy, NY, Nov. 2000 <http://www.center.rpi.edu/pewgrant/rd1award/PSU.html>.

[36] "The Pew Grant Program in Course Redesign. Round 1 Grant Awards. University of Southern Maine. Course Title: Introductory Psychology," Center for Academic Transformation, Rensselaer Polytechnic University, Nov. 2000 <http://www.center.rpi.edu/pewgrant/rd1award/maine.html>.

[37] Farnsworth studied the effectiveness of computer simulations in veterinary classes. "Over the course of the simulations, student diagnostic ability improved, showing 'a significant relationship between repeated use of case simulations...and increase in diagnostic efficiency'" (Jay Sivin-Kachala and Ellen R. Bialo, "The 2000 Research Report on the Effectiveness of Technology in Schools, 7th Edition," published for the Software Information Industry Association (2000): 15).

[38] David Ota, Bowen Loftin, Tim Saito, Robert Lea, and James Keller, "Virtual Reality in Surgical Education,"(1995) Division of Surgical Oncology, University of Missouri, 7 Oct. 2000 <http://www.vetl.uh.edu/surgery/vrse.html >.

[39] Ways Technology Can Make Learning More Exciting

Teachers are employing technology in innovative ways that enhance student learning (Weiner, "Teachers").

- Fifth grade teacher Jeff Wataha, a teacher at Lakewood Elementary School in Overland Park, Kansas asks his students to "'create their own personal Web pages. They put on work created throughout the year so their parents, grandparents and friends around the country can see it through a password-protected Web page."

- In an effort to tie classroom work to extracurricular activities, Amy Fiske, a teacher of third and fourth grades at Amherst Street School in Nashua, NH has had her students participate in online chats with authors after reading their books. She states, "it provides them a chance to see the world in real time."

The California State University System's Integrated Technology Strategy has developed a new component called Biology Labs On-Line. The aim of this project to allow students to "carry out many more experiments than would be possible with real labs." Among some of the labs is the fly lab, which allows students to study genetics by computer mediated breeding of flies. The TranslationLab, a molecular biology lab, allows students to create simple RNA molecules, from which information of the genetic code can be deduced. Whereas such experiments would take months in a real lab, Biology Lab On-Line allows students to see results in minutes (Bell).

Several Universities in Australia are using Interactive multimedia to train students in nursing school. The CD-ROM program makes use of simulations that present "many of the complexities of life in a typical hospital ward, making the education of graduate nurses and students case-based and authentic. The "Goal-Based Scenarios" used in the simulations allow students to develop important problem solving skills as well as fundamental knowledge of procedures. Students receive feedback by viewing a mock "case conference" in which practitioners give a criticism of the student's work (Naidu).

Rebecca S. Weiner, "Teachers Question Critical Study of Classroom Computers," New York Times on the Web 26 Sept. 2000, 27 Sept. 2000 <www.nytimes.com/2000/09/26/technology/27EDUCATION.html>;

Jeffrey Bell, "The Biology Labs On-Line Project: Producing Educational Simulations That Promote Active Learning," Interactive Multimedia Electronic Journal of Computer-Enhanced Learning, Wake Forest University October 1999, 21 March 2001 <http://imej.wfu.edu/articles/1999/2/01/printver.asp>;

Som Naidu, Mary Oliver, Andy Koronios, "Approaching Clinical Decision Making in Nursing Practice with Interactive Multimedia and Case-Based Reasoning," Interactive Multimedia Electronic Journal of Computer-Enhanced Learning 1.2, Wake Forest University October 1999, 23 March 2001 <http://www.imej.wfu.edu/articles/1999/2/03/printver.asp>.

The George Lucas Educational Foundation offers a look, through video, into an interactive classroom. Here you get a view into a San Jose classroom that is using multi-media technology to learn science. Students integrate field research, Internet research and group work to learn about insects. The eight video clips show you how technology, for these students, has enhanced their learning and made science much more exciting. See: <http://glef.org/FMPro?-db=learnlivekeywords1.fp5&-lay=layout%20%231&-Format=keyword.html&-max=200&jargonfree==Technology%20Integration&-sortfield=show%20order&-SortOrder=ascend&-find> for an in depth look.

[40] The Pew Learning and Technology Program Newsletter offers a look at course redesign at various institutions and how technology has altered the pedagogy, engaging students in learning at lowered costs. Click here <http://www.center.rpi.edu/PewGrant.html> for more information on course redesign at Carnegie Mellon, University of Massachusetts at Amherst, and others.

[41] Digital Technology Is Changing How Students Learn

Professor Steven Donahue, of Broward Community College in Florida, uses technology to teach E.S.L. students pronunciation. Students record themselves speaking and e-mail the file to the professor. Mr. Donahue uses software to analyze the speech patterns of his students in order to check for mispronunciations. Professor Donahue believes that the online program is superior to the traditional classroom because "just looking at someone's mouth doesn't give you enough information about their pronunciation" (Carr, "Professor").

The University of Idaho and Tyler Junior College provide studio-art classes online. By creating art online, professors can make comments directly on student's work (Young, "Studio-Art").

Professor Loreto Sanchez of UMUC teaches her students Spanish online by using computers with built-in microphones to conduct weekly ten-minute conversations. "In a regular classroom, Sanchez says, 'I'd have to cut them off after three minutes to let the other students talk'" (Weiss).

The HEI Training Services has included with its forklift instruction manual a CD-ROM and steering wheel ensemble that allows for direct forklift simulation. This teaches operation as well as safety through computer mediated, yet hands-on learning (Hughes).

Sarah Carr, "A Professor Goes Online to Teach Pronunciation," Chronicle of Higher Education 30 June 2000: A44;

Jeffery R. Young, "Studio-Art Instructors Try Teaching Online, and Say It Works," Chronicle of Higher Education Online 28 June 2000, June 2000 <http://www.chronicle.com/ >;

Stefanie Weiss, "Virtual Education 101," Washington Post 9 Apr. 2000: W31;

Frank Hughes, demonstration, Project Kaleidoscope Conference, Dallas, March 3rd 2001.

According to, e-Learning, a recent report released by the U.S. Department of Education, technologies "...help students to visualize difficult to understand concepts....Visualization and modeling software similar to the tools used in the workplace increase students' conceptual understanding. Since new technologies are interactive, it is now easier to create environments in which students can engage in learning, receive feedback, and continually refine their understanding" ("e-Learning," published for the Office of Educational Technology, U.S Department of Education, Washington DC, December 2000: 25. <http://www.ed.gov/Technology/elearning/e-learning.pdf>)

[42] "Competitive forces will cause more practical and relevant courses to be built and soon college introductory courses will focus on how to run a business rather than the theory of micro-economics or how to use chemistry as a doctor rather than principles of organic chemistry," (Roger Schank and Kemi Jona, "Extra-curriculars as the Curriculum: A Vision of Education for the 21st Century," presented at the "Forum on Technology in Education: Envisioning the Future," Conference, United States Department of Education, Washington DC, December 1-2, 1999, 21 March 2001 <http://www.air-c.org/forum/Schank.pdf>).

[43] "Results from the Questionnaire for User Interaction Satisfaction (QUIS) showed that in general, students have rated their learning experiences in the electronic classrooms consistently higher than their learning experiences in traditional classrooms. Students reported that they learned more, the class was more interesting, and that they were more motivated. They also thought they had a greater opportunity to be heard by the instructor and that they heard more from their classmates," (Ben Shneiderman, et al., "Emergent Patterns of Teaching/Learning in Electronic Classrooms," Educational Technology Research & Development 46.4 (1998): 23-42).

[44] An example of online instruction includes the server-based application "Mastering Chemistry" designed by Patrick Wegner at the California State University at Fullerton. The focus of this server is to encourage "self-paced, individualized and automated assessment" by collecting and storing data on the student each time the server is utilized. Visit http://mc.nacs.uci.edu to view the application (Ramesh D. Arasasingham, "Enhancing Learning Using Server-Based Tools in

General Chemistry," presented at the Change Agents Roundtable: "How Can Information Technology Be Best Used to Enhance Undergraduate SME&T" conference, March 2001, Project Kaleidoscope, 9 March 2001 <http://www.pkal.org/events/car2001/arasasingham.html>).

[45] For a thorough analysis of the growing competition among providers of higher education, see Frank Newman and Lara Couturier, "The New Competitive Arena: Market Forces Invade the Academy," 26 Jan. 2001, 23 Feb. 2001<www.futuresproject.org>.

[46] Douglas Blair, director of production and client services in Princeton University's Alumni Council, "designed web-based courses for alumni education programs." He commented, "'We provide complete support... Faculty members don't have to learn the creative process from the technological point of view and they don't have to learn the software which often quickly becomes out of date'" (Ruth Stevens, "Center is one-stop shop for teaching technology," Princeton Weekly Bulletin, 20 Nov. 2000, 30 Jan. 2001 <http://www.princeton.edu:80/pr/pwb/00/1120/index.shtml>).

In addition, Yale's Center for Media Initiatives, Carnegie Mellon's Center for Innovation in Learning, as well as Wake Forest University's International Center for Computer Enhanced Learning offer faculty support and expert advise in restructuring and/or incorporating technology into the curricula, ("Media Laboratory at the CMI," About CMI, Yale University, New Haven, 20 December 2000, 23 March 2001 <http://www.yale.edu/cmi/media_lab/index.html>; "Mission," Center for Innovation in Learning, Carnegie Mellon University, 23 March 2001 <http://cil.andrew.cmu.edu/mission.html>; "Training," International Center for Computer Enhanced Learning, Wake Forest University <http://iccel.wfu.edu/training/index.html>).

[47] Students are Arriving at the University's Door with Even Greater Skills for Using the New Technologies.

There is a "generation of undergraduate students who have been raised on 56K and higher band-width access to multimedia and the world wide web... these students are technologically literate and prefer to utilize learning materials that are fluid, manipulative, open-ended, and very visual." This can conflict with the opinions and literacy of many of their teachers (Cotten).

The University of Massachusetts-Amherst conducted a five-year investigation of the trends in college students' use and ownership of computers (Kuenzi). Findings include:

- The number of students who had never used a computer dropped 200 percent: from 15% in 1991 to 6% in 1996.

- Almost 30% of students owned a computer in 1991 while nearly half (45%) owned a computer in 1996.
- In 1991, 10% of students used e-mail, compared to 67% in 1996.

A survey at California State University, Long Beach comparing undergraduate business students in 1990 and 1996 found that (Khan):

- Familiarity with database software increased from 22% in 1990 to 46% in 1996.
- Familiarity with spreadsheet software increased from 28% in 1990 to 43% in 1996.
- Word processing skills increased from 54% in 1990 to 77% in 1996.

Catherine P. Cotten, "The Southeast Consortium for Advanced Network Technology Education," presented at the Change Agents Roundtable: "How Can Information Technology Be Best Used to Enhance Undergraduate SME&T" conference, March 2001, Project Kaleidoscope, 8 March 2001 <http://www.pkal.org/events/car2001/cotten/html>;

Jeffery J. Kuenzi, "Trends in College Students' Computer Use and Ownership," Journal of Educational Technology Systems 28.1 (1999-2000): 21-31;

M. B. Khan, "Changing Computer Skills of Incoming Undergraduate Business Majors," Journal of Educational Technology Systems 28.1 (1997-98): 55-66.

The following is taken directly from Frank Newman and Lara Couturier "The New Competitive Arena: Market Forces Invade the Academy," 26 Jan. 2001, 23 Feb. 2001<www.futuresproject.org>.

Computer Access at Home and in the Schools

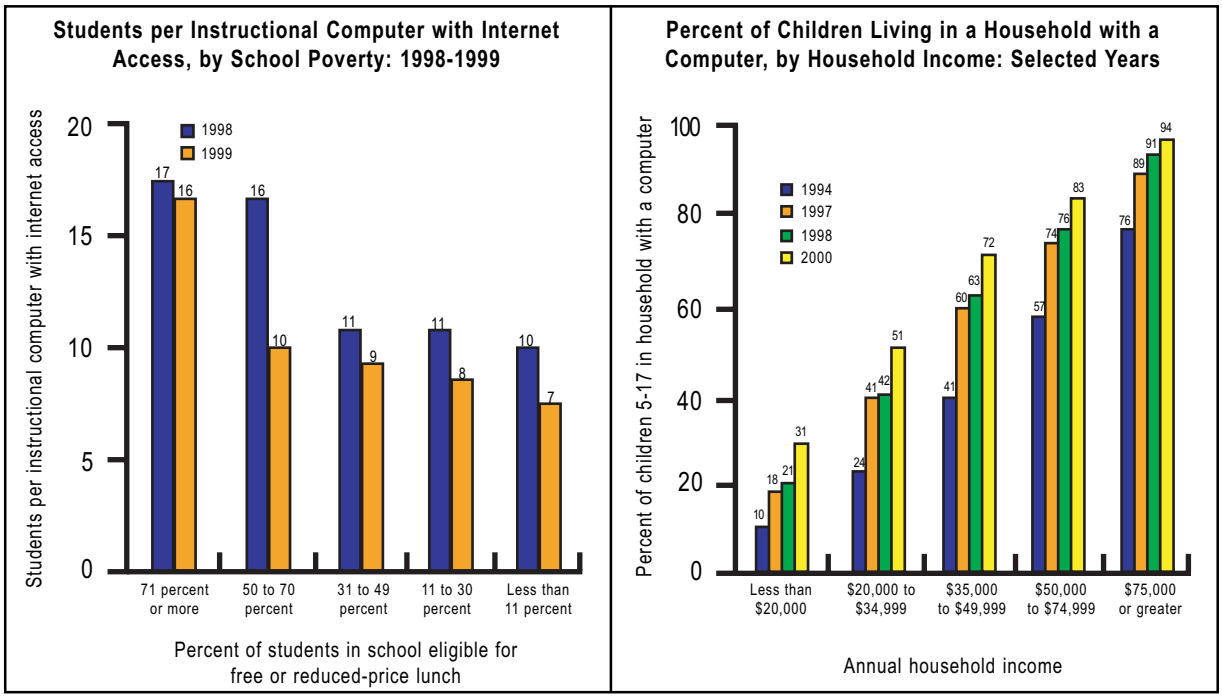
According to the National Center for Education Statistics, the percentage of public schools with Internet access has increased dramatically in recent years. While just 35% of American public schools had access in 1994, that number nearly tripled by 1999, with 95% of schools having access (94% access in elementary schools, 98% in secondary schools). NCES also reports that the percent of instructional rooms with Internet access in public schools has risen from 3% in 1994 to 63% in 1999. The number of students per instructional computer with Internet access has fallen from 12 % in 1998 to 9% in 1999, with the number continuing to drop. See U.S. Department of Education, National Center for Education Statistics, Internet Access in U.S. Public Schools and Classrooms: 1994-1999, NCES 2000-086 (Washington DC: U.S. Government Printing Office, Feb 2000), <www.nces.ed.gov>.

Computer access at home is another important indicator of computer literacy. According to NCES, the percentage of fourth-grade students who reported using a computer at home was higher in 1997 than in 1984. The number rose

from 13 to 45 percent. U.S. Department of Education, National Center for Education Statistics, "Student Computer Use," The Condition of Education, 1999, NCES 1999-022 (Washington, DC: U.S. Government Printing Office, 1999) 10, www.nces.ed.gov.

The following two charts are taken directly from, "E-Learning, Putting A World - Class Education at the Fingertips of all Children."

The Digital Divide in Schools and Homes



Source: Census Bureau, Current Population Survey: November 1994, October 1997, December 1998 and August 2000.

Source: "Internet Access in U.S. Public Schools and Classrooms: 1994-1999," published for the National Center for Education Statistics, NCES 2000-086, U.S. Department of Education, Washington DC. February 2000, 9 April 2001 <http://www.nces.ed.gov/pubsearch/pubsinfo.asp?pubid=2000086>

"e-Learning," published for the Office of Educational Technology, U.S Department of Education, Washington DC, December 2000: 25. <http://www.ed.gov/Technology/elearning/e-learning.pdf> 19-20;

[48] "Two-thirds (65.8 percent) of the campus officials participating in the 2000 Campus Computing Survey report that their institution has a strategic plan for information technology. However, when asked for additional information about these plans, a number of key components appear missing" (Kenneth C. Green, "Struggling with IT Staffing," The 2000 National Survey of Information Technology in US Higher Education, published for the Campus Computing Project, Encino, California, Oct. 2000, 13 Feb. 2001 <http://www.campuscomputing.net/summaries/2000/index.html>).

Noteworthy Strategy Plans:

Strategy Plan	Institution
Teaching, Learning, and Technology	University of Notre Dame
e-Strategy	University of Warwick
Goals 2005	Bates College

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