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## *Higher Education in the Digital Rapids*

### **The Futures Project: Policy for Higher Education in a Changing World**

Frank Newman and Jamie Scurry

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*Ed. Note: On May 2, 2001, Lara Couturier and Jamie Scurry, project managers for the Futures Project, made a presentation at a Sheridan Center Teaching Forum. During a lively discussion, many faculty were interested in the current state of research on the effectiveness of using technology in higher education. Project director Frank Newman and Jamie Scurry have permitted the Sheridan Center to print a preliminary version of the results of their work. A full version of the text is available at [www.futuresproject.org](http://www.futuresproject.org).*

*\* in the text indicate a footnote with full references to the works or examples cited. Using the electronic version, it will be easy for readers to access the many links to recent data on the use of instructional technology in higher education. We urge faculty and graduate students to take time to study this material and use it to develop strategies for implementation in their own courses where appropriate.*

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.

## Student Reactions\*

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. 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.

"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."\*

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.\* 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.\* 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.\* 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.\*

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.\* 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.\* 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.\*

## Technology Aids Learning\*

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.\* 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.\*

Examples of computer mediated simulations from the ***Biology Labs On-Line Project***.\*

- a. **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.
- b. **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.
- c. **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.
- d. **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***:

<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.\*

## What Gives Technology its Learning Power?

*"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."\* (e-Learning)*

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.\* 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."\* Digital technology can provide professors with a practical approach to those methods that have been recognized as far more effective than lecturing.\* Tanya Furman, Associate Professor and Undergraduate Program Head, Department of Geosciences, 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."\*

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"\*

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.\*

## **Digital Technology Provides Practical Ways to:**

### **1. 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."\*

Speech pathology students can manipulate a virtual skull to see how the jaws and tongue move in response to certain muscles.\*

<http://www.lib.uiowa.edu/commons/skullvr/background.html> has a complete demonstration. 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."\*

## **2. Connect learning with real life\***

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.\*

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.\*

## **3. Provide ready, rapid, and interest-generating access to massive amounts of information in ways that encourage students to search, explore and combine information\***

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.\* 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.\*

#### **4. 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.\* 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, adjust future class discussions or provide individual counseling accordingly.\*

#### **5. Allow students to easily return to previously covered material (asynchronous learning)\***

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.

#### **6. Encourage 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."\* 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.\*

### **7. Another advantage is the ability to provide preliminary experience in a safe setting.\***

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."\*

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.\* 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.\* 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 the electronic version of Appendix A): online courses, elementary and secondary schools, skill training centers, as well as traditional classrooms.\* 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\* Each will encourage active learning and frequent communication with the faculty member and other students.\* 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.\*

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.\* 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.\*

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.\* 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.\* 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

Below are links to interactive software, simulations, course modules, 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	
Peter Shearman & Roni Linser, World Politics in Transition Simulation	<a href="http://ariel.ucs.unimelb.edu.au/~ronilins/WPT/SimHome.html">http://ariel.ucs.unimelb.edu.au/~ronilins/WPT/SimHome.html</a>
Mastering Chemistry Learning Server	<a href="http://mc.nacs.uci.edu/">http://mc.nacs.uci.edu/</a>
Stanford Learning Lab Courselet Project	<a href="http://learninglab.stanford.edu/index.cgi">http://learninglab.stanford.edu/index.cgi</a>

James Walker's Solar System Live	<a href="http://www.fourmilab.ch/solar/solar.html">http://www.fourmilab.ch/solar/solar.html</a>
Purdue's Online English Lab: OWL	<a href="http://www.owl.english.purdue.edu/lab">www.owl.english.purdue.edu/lab</a>
The Math Forum	<a href="http://www.mathforum.com">www.mathforum.com</a>
Forest Biology and Dendrology Educational Sites at Virginia Tech	<a href="http://www.fw.vt.edu/dendro/">Http://www.fw.vt.edu/dendro/</a>
Project Kaleidoscope: Papers: How can information technology enhance undergraduate education in science, mathematics, engineering and technology	<a href="http://www.pkal.org/events/car_2001/summaries.html">www.pkal.org/events/car_2001/summaries.html</a>
Biology Labs Online Preview and Biology Labs Online	<a href="http://www.aw.com/bc/blol">www.aw.com/bc/blol</a> and <a href="http://www.biologylab.awlonline.com/">http://www.biologylab.awlonline.com/</a>
ICONS Simulation (the International Communication and Negotiation Simulation)	<a href="http://www.bsos.umd.edu/icons/">http://www.bsos.umd.edu/icons/</a>
UC-Berkeley's Center for Community Economic Research - The National Budget Simulation	<a href="http://garnet.berkeley.edu:3333/budget/budget.html">http://garnet.berkeley.edu:3333/budget/budget.html</a>
The University of Iowa: Virtual Hospital Program	<a href="http://www.vh.org/Providers/Simulations/PatientSimulations.html">http://www.vh.org/Providers/Simulations/PatientSimulations.html</a>
Syracuse University Physics — Gravity Simulation	<a href="http://www.phy.syr.edu/research/education/java/SUorbitnew/SUorbitnew2.html">http://www.phy.syr.edu/research/education/java/SUorbitnew/SUorbitnew2.html</a>
Syracuse University Physics — Twin Paradox, The Light Cone	<a href="http://www.phy.syr.edu/courses/modules/LIGHTCONE/java/TwinParadox.html">http://www.phy.syr.edu/courses/modules/LIGHTCONE/java/TwinParadox.html</a>
Syracuse University	<a href="http://www.phy.syr.edu/courses/java-suite/crosspro.html">http://www.phy.syr.edu/courses/java-suite/crosspro.html</a>

Physics — The Vector Cross Product	
Syracuse University Physics — Educational Modules and Simulations	<a href="http://www.phy.syr.edu/courses/modsim.html">http://www.phy.syr.edu/courses/modsim.html</a>
Columbia University's King Lear	<a href="http://ccnmtl.columbia.edu/services/showcase/lear.html">http://ccnmtl.columbia.edu/services/showcase/lear.html</a>
Virginia's Uncle Tom's Cabin	<a href="http://www.iath.virginia.edu/utc/">http://www.iath.virginia.edu/utc/</a>
BioQuest Curriculum Consortia	<a href="http://www.bioquest.org/">http://www.bioquest.org/</a>
The George Lucas Educational Foundation	<a href="http://glef.org/index.html">http://glef.org/index.html</a>
Princeton Online Poetry Project	<a href="http://www.princeton.edu/online-poetry/">www.princeton.edu/online-poetry/</a>
Wake Forest Interactive Multimedia Electronic Journal of Computer-Enhanced Learning and the International Center for Computer Enhanced Learning	<a href="http://www.imej.wfu.edu">www.imej.wfu.edu</a> and <a href="http://iccel.wfu.edu">http://iccel.wfu.edu</a>
Yale Center for Media Initiatives	<a href="http://www.yale.edu/cmi">http://www.yale.edu/cmi</a>
Princeton University: Educational Technologies Center	<a href="http://www.princeton.edu/pr/pwb/00/1120/index.shtml">http://www.princeton.edu/pr/pwb/00/1120/index.shtml</a>
Carnegie Mellon: Center for Innovation in Learning	<a href="http://cil.andrew.cmu.edu">http://cil.andrew.cmu.edu</a>
Columbia Center for New Media Teaching and Learning	<a href="http://ccnmtl.columbia.edu/">http://ccnmtl.columbia.edu/</a>