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CHAPTER 8

The Real Versus the Possible: Closing the Gaps in Engagement and Learning

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The Next Generation of Learners

It is natural to assume that each generation can be described easily, and we often use labels such as Generation X or the Net Generation to describe generational differences. In thinking about educating the next generation, it is helpful to realize that not everyone is a member of the Net Generation—not because of age but because of access to technology. Many students, both in K–12 and in postsecondary education, have only limited access to advanced instructional technologies or to the Web. Although technology-enabled interactive instruction may be highly engaging, many students, teachers, and faculty have no experience with it. One study found that in spite of the fact that 99 percent of K–12 schools have Internet access, as do most classrooms (87 percent), these resources are rarely used effectively.[1]

While high-speed classroom connectivity is good, most actual Internet usage takes place in media centers or computer labs. This suggests that Internet resources are not yet fully integrated into the day-to-day classroom routine. In fact, 56 percent of respondents to the study identified integrating technology into the classroom or learning experience as their top technology challenge. The same percentage (56 percent) named teacher professional development as their top challenge, a finding consistent with an earlier Pew study.[2] Through 14 national, diverse focus groups, students reported a substantial disconnect between how they use the Internet for school and how they use it during the school day and under teacher direction. Fundamental changes in school organization, time management, and teacher preparation will be needed to generate the most value from this massive investment in technology. These changes will affect what students and teachers do in the classroom.

The experience of students in the introduction and use of instructional technologies in school varies widely. The 2004 National Research Council report on fostering high school students' motivation to learn argued that motivation is a key factor in the success or failure of education and that "by the time many students enter high school, disengagement from course work and serious study is common."[3] The consequences of this disengagement are often much more serious for young people from disadvantaged backgrounds because they do not usually get a second chance; students from more privileged backgrounds frequently do. The primary ingredients that foster involvement and motivation to learn are "competence and control, beliefs about the value of education, and a sense of belonging."[4] These personal factors work within a complex convergence of other more visible things such as curriculum, instruction, the organization and management of the schools, and the conditions in the community surrounding the schools.

The Board on Children, Youth, and Families, which produced the 2004 National Research Council report, offered a research-based set of recommendations for what we can do to keep young people in school, make high school meaningful, and keep students engaged and motivated. The ideas include

- forming a good connection between a learner and the social context in which learning will take place; and
- making "the curriculum and instruction relevant to adolescents' experiences, cultures, and long-term goals, so that students see some value in the high school curriculum."[5]

These recommendations will serve as an interesting starting point for exploring the role and impact of interactive instructional technologies in education, both in K–12 and in postsecondary education.

Similar conditions exist in K–12 and higher education. Connectivity investments, particularly wireless, are growing (81.1 percent of the campuses participating in the 2004 Campus Computing Survey reported wireless LANs, up from 77.2 percent in 2003, 67.9 percent in 2002, and 29.6 percent in 2000).[6] Internet usage is very high among 18–29-year-olds in the general population (78 percent) and among those with some college experience (75 percent), or those with at least four years of college (88 percent).[7] Only 38 percent of college students, however, reported using the Internet for work in classes. Instead, the Internet is used primarily to communicate.

While undergraduates reported a positive impact of the Internet on their academic experience, a closer read of the data reveals that IT usage beyond e-mail remains relatively low. For example, only 6 percent of students reported taking an online course for credit, and only half of the students in this group reported that the course was worthwhile. Moreover, while students and faculty are communicating by e-mail, it appears that the communication is primarily about procedural matters: absences, homework assignment questions, grades, review session schedules, and the like. Students did report, however, that e-mail permits them to communicate ideas to faculty they otherwise might not have expressed face-to-face.

Approximately 25 percent of the students enrolled in postsecondary education are traditional students pursuing traditional pathways and traditional goals. Traditional students enter college immediately after graduation from high school, attend full time, usually work only part time, and are financially dependent on their families. Nontraditional students may differ on a number of characteristics, such as entering postsecondary education as an adult student, attending part time, working full time while enrolled, or being financially independent. Approximately 28 percent of postsecondary students are single parents or have not graduated from high school, having instead completed a GED. Nontraditional students are less likely than traditional ones to complete a degree and are more likely to begin their postsecondary education in a community college or a private for-profit institution. Their pathway to a degree is complex, and the yield of successful bachelor's graduates is low compared to traditional or nontraditional students who begin their postsecondary education at a four-year institution. What kinds of educational experience will engage these students? How might interactive technologies enrich their education, maintain their commitment to learning, and help them succeed? Beyond nontraditional learners, what about the significant proportion of "traditional" undergraduates who fail to complete a degree? Might interactive instruction help them to experience competence and control, develop an appreciation for the value of an education, and feel a part of a learning community?

As we think about what all high school students and undergraduates should learn and how interactive technologies might contribute to effective education, it is helpful to keep two larger issues in mind:

- At the most basic level, educational technologies are a means to a good education. If we lose sight of what it will mean to be educated in the 21st century, we will not be able to connect our new technological capabilities to the underlying purposes for which they should be used.
- We need to think about interactive technologies in the context of what we know about how to promote learning.

Learning and Technology

The emergence of new technology challenges our assumptions about the nature and locus of learning. In turn, advances in the learning sciences reveal new possibilities for the application of technology in support of educational goals centered on the engaged learner.

What We Know About Learning

Although we know a lot about learning[8] and continue to learn more, there is a gap between what the education research community and the learning sciences have discovered about learning and what most of our faculty know or practice. Because faculty develop and implement most of the content and teaching practices, this gap impacts

- the development of materials for interactive technology,
- what faculty incorporate into their teaching, and
- the design of the curriculum.

We need to find creative ways to close that gap by encouraging our faculty and their graduate students to take educational issues seriously. We must also approach the development of interactive technologies and programming with the same rigor, discipline, and habits of inquiry that faculty bring to their own research agendas.

Goals of Education

All fields have their own vocabulary, ways of talking about ideas, standards of proof, and methodologies. Undergraduates should become acquainted with these "ways of knowing," not just because they are a necessary part of becoming a professional but because they may offer insights into other disciplines. Students should not be asked to abandon scientific thinking when they study humanities, for example. Science and math are important components of the liberal arts. A major in science or math should not only prepare students to pursue a career in their field but also foster the desired qualities of a liberally educated person, regardless of discipline. We must prepare all young people for lives of creativity, citizenship, and social responsibility as well as success in a workplace increasingly shaped by science and technology. This requires us to think about the meaning of literacy and the way we "read" the world around us. Interactive instruction can offer an especially engaging way to learn this skill. In addition to learning the habits of mind, forms of expression, and inquiry of a discipline, students should be expected to demonstrate the qualities of a person prepared to live a productive, creative, and responsible life.

There are many approaches to articulating the purposes of a college education. All involve bringing together intellectual engagement and cognitive development with emotional maturity and social responsibility. A college graduate should be informed, open-minded, and empathetic. These qualities are not engendered solely by general education in the first two years of college. Academic departments must build these expectations into their conception of the work of the major as well. It is helpful to think of an undergraduate education as a continuum of increasingly complex intellectual challenges, accompanied by increasingly complex applications, with consequences of increasing significance for the learner and others. A special emphasis should be placed on preparing our technical workforce to communicate with the general public and with policymakers. Interactive instruction must build in both cognitive and affective domains in order to give students experience with responsible learning and practice.

The Promise and Limitations of Technology

Since the introduction of the World Wide Web, we have seen dramatic advances in the communication capabilities of the Internet. Continued improvements in the underlying hardware and software infrastructure have stimulated growth in the number of access points, bandwidth, and new transmission technologies (DSL, cable modems, satellite), with no end to this growth in sight. Emergent wireless technologies, from Wi-Fi to WiMax,[9] promise to "untether" users, enabling unforeseen applications of the Internet that challenge our assumptions about user behavior and information needs.

Concurrently, the commodification of computation has lowered the financial barriers to Internet access for individuals. Low-cost fixed and mobile computers are more available, as are a variety of even lower-cost devices that blur the lines between cell phones and personal digital assistants. Tremendous increases in computational power have also enabled the development of rich multimedia capabilities that offer greater levels of interactivity for the user's experience via modeling, animations, simulations, voice, and other audio applications.

Finally, new applications are changing the nature of the Web and the way in which users—and learners—can interact. Individuals may now more easily express themselves, contribute their commentary, provide expertise, and otherwise participate in potentially wide-ranging conversations. Ubiquitous, one-to-one computing places greater control "at the edge" of the network. Thus, instant messaging and other variants of peer-to-peer communication, along with blogging and other self-publishing models, are enabling content, commentary, and community to commingle at an unprecedented scale.

In his essay on technological revolutions that he has known, Edward Ayers made clear that the real impact of new technologies only becomes manifest when the "machine as a separate box needing elaborate maintenance and full attention"[10] fades into the background. At that point the new capabilities can be effectively integrated into teaching and learning. As Ayers put it, "It is not until we find ways to integrate electronic teaching (and learning) into our established rhythms, strategies, and purposes that the very real potential of the new media will begin to be realized."[11] IT will not replace older forms of learning or teaching because each type of interaction between instructors and students accomplishes a unique goal. However, it will open up new and engaging ways to learn. So what is that very real potential?

Ayers argued that we need a balance of individual and active learning, along with collaborative learning and passive learning, which occurs in groups and through lectures. A live lecture has its place. It is a way for a dedicated and passionate scholar to dramatize and embody the intellectual content of a subject and demonstrate the appeal and importance of the material. It is important for students to see not only *what* they need to know, but also *why* it is important. Reading also has its place. Reading "is the most individualized, active, and reflective intellectual activity and as such is the measure for intellectual work in general."[12] Of course, reading can also be deadly and boring when the reader is trapped in a technical frame that is unfamiliar in content, structure, vocabulary, or forms of expression. The important insight that will guide our exploration of the value of interactive technologies is that a user of digital information is certainly being asked to be active, but is probably not being asked to be reflective. "The computer, unlike a text, is built for action; it sits there humming, waiting, demanding that you punch some key or click some button. It is distracting, perpetually promising something more interesting than your own unfocused thoughts or the words currently before you on the screen."[13]

As we explore the newer forms of interactive technologies, whether live ones on the Web or multimedia presentations on DVDs, we must keep in mind that these are not meant to replace traditional forms of learning. Rather, they enrich traditional forms of learning and serve as links between active and passive, individual and group, and transmission and generation of knowledge. The criteria we apply when assessing the *quality* of the material we offer will, at one level, resemble the standards that the academy has set for any intellectual work: originality and importance, thorough grounding in the field, clarity of goals and expression, effective use of materials, and ethical handling of material and ethical approach to the user.[14] However, The standards for *presentation* in these new media and formats will be different. We must be clear about when an interactive instructional strategy is appropriate and when it is not. In most cases, experience with an interactive program branches and adapts to the user. It does not encourage a "linear argument or narrative nearly as well as a book"[15] or convey, as a live performance or a group discussion can, the passion and personality of an engaged learner and scholar.

Interaction

The Net Generation has been described as experiential, engaged, and constantly connected, with a strong need for immediacy. For all learners, research points to the importance of learning environments which are active, social, and learner-centered. These environments might be described as interactive. Information technology supports at least four major categories of interactivity.

People to People

People to people interactions may be synchronous or asynchronous; they can take place in the same place or at a distance. In education, there can be one-to-many communication (for example, between faculty and students); however, information technology's power rests in its ability to enable this traditional communication mode to take on a bidirectional character. Many-to-many communication (students to students, faculty to faculty, or students to faculty) may occur in a vertical learning community. In addition, one-to-one peer mentoring is facilitated by IT. The work of the Math Forum (http://www.mathforum.org/) provides a good example of how the process of communication about content (in this particular case, mathematics) can exhibit symmetric (same level of preparation and background) and asymmetric (novice with expert) modes. In addition, the online setting permits subtle renegotiation of roles within the conversation and introduces a balancing effect among participants.

People and Tools

A second category involves interaction between *people and tools.* An example is a distributed computing environment that can involve a single user making use of distributed computational resources, or multiple users who are at a distance making use of a computing resource, whether centralized or distributed. Another example is provided by what might be termed a distributed observational environment, which can feature one-to-many or many-to-one modes. Through the Sloan Digital Sky Survey project (http://www.sdss.org/), a vast network of professional and amateur astronomers can interact at any time with the same vast data storehouse of information rather than wait sequentially for an opportunity to use a single telescope. And the data in the survey comes from a distributed network of observational platforms. A similar example is the One Sky, Many Voices project (http://groundhog.sprl.umich.edu/) that engages school children in distributed data collection and analysis. Students can submit their results to a larger community for scrutiny and use, ensuring that novice learners feel ownership of their intellectual activity. These examples illustrate the Internet's ability to provide access to data, either derived (from models) or directly observed. They also illustrate how instrumentation may be remotely accessed.

People with Concepts

The interaction of *people with concepts* is a third category in which an information technology device, rather than being a tool itself, is the vehicle by which concepts are presented or rendered. For example, image databases such as two-dimensional slices of objects (both animate and inanimate) illustrate the complex geometry and physical relationships of constituent parts. More abstractly, interrelationships among concepts and/or numerical data can be represented visually.[16a,b] Simulations and animations also fall into this category. They are often "steerable" or controllable through a graphical user interface. The underlying data that is represented visually can be manipulated in varying ways, often revealing patterns and relationships not immediately visible in the standard tabular or serial formats of the original data. Virtual reality environments fall into this category; they permit the learner to work with concepts and their representations in a dynamic, interactive manner.

People with Contexts

The fourth category involves the interaction of *people with contexts.* Various forms of rich-media communication enable people to interact with each other. Collaboration enhanced by interaction with tools and organized around interaction with concepts fosters the development of community. This larger context situates learning. Norms of interaction and contribution grow from within the community and include processes by which a collective understanding develops about a core amount of definable knowledge that "everyone should know." This leads to several questions, however. How should the learner come to know this core? How is this demonstrated? How is it certified? Can learners demonstrate their competence individually? How do members of the community attain authority or otherwise receive certification of competence?

Examples

Examples from K–12 and higher education illustrate how education can be made more interactive, resulting in better engagement for the Net Generation and other learners.

Animation

Simple animations, even with relatively limited interaction, can promote conceptual learning. A particularly compelling example depicts three standard sorting algorithms.[17] It animates the effect of the algorithms on the task of ordering (from shortest to longest) a random set of different length line segments. Not only can users see the way each algorithm makes its choices, but they can also compare the relative speeds of each by determining when to start each demo so that they will all finish their respective sort at the same time.

Concept Inventories

Since David Hestenes's pioneering work on the development of the Force Concept Inventory (http://modeling.la.asu.edu/R&E/FCI.PDF), numerous other disciplines and subdisciplines such as mechanical engineering and civil engineering have developed similar "diagnostic tests" to help faculty ascertain student conceptual understanding.[18] Typically, concept inventories are used in large-enrollment courses. A hallmark of these inventories is their interactive implementation. The faculty member poses questions, and short student responses are recorded and aggregated. Information technology has enabled the rapid recording, analysis, and representation of the results, making the technique particularly attractive in large-enrollment settings. A notable practitioner of this technique is Harvard physics professor, Eric Mazur.[19]

It is worth noting that an information technology overlay is not necessary for useful implementation of the approach; however, the development of low-cost wireless interactive response systems[20] and accompanying receiving stations allows the concept test approach to be implemented at reasonable cost. At the most rudimentary level, interactive response systems are used as polling devices. The interaction is mostly one way; however, the real-time snapshot of a group's understanding contributes directly to the faculty member's understanding of what conceptual emphases are needed based on the class's progress.

WeBWorK

An example of a distributed system for providing feedback on student work for the sake of building conceptual understanding is WeBWorK (http://webwork.math.rochester.edu/). WeBWorK, developed by mathematics faculty, begins with the assumption that doing homework is still important, especially problems that provide "practice" in certain basic levels of rote computation. But faculty believed that this should not be the sole learning assessment in a course. Therefore, they created an automated homework grading system that places the responsibility for homework exercises on students while providing interactive feedback along the way. This frees up significant time, both in and out of class, enabling faculty and graduate teaching assistants to deal with conceptual learning. This goal has been achieved. The number of installations of WeBWorK at other mathematics departments has grown steadily. Moreover, departments outside mathematics are beginning to use the system.

AskNSDL

AskNSDL (http://www.nsdl.org/asknsdl/) is the electronic reference service of the National Science Digital Library. This service illustrates interactive engagement between novice learners (question posers) and experts (providers of responses) that occurs both at a distance and asynchronously. As such, it is a many-to-many and people-to-people form of interaction. A notable feature of the service is that it harnesses expertise that is widely distributed in both a geographic and a disciplinary sense. AskNSDL is currently considering the engendering of virtual communities of experts that would exist for a concentrated period of time (for example, during National Chemistry Week or other similar celebrations).

The Molecular Workbench

More complex simulation environments such as the Molecular Workbench developed by the Concord Consortium (http://workbench.concord.org/) offer what is essentially an entire virtual environment in which to carry out experimentation, observation, and analysis. Model comparisons are possible; moreover, the user can control parameters that affect both the choice of models and parameters within any given model. This particular environment also has 3-D representations that can be manipulated. At one level, this is a very rich interactive environment in the *people and tools* category, but it also supports both *people with concepts* and *people with contexts* interaction if it is used intentionally by a group of learners with guidance from an "expert." Such an expert might start out as the teacher or faculty member, but could build in expectations for students to become peer mentors and thus improve their own learning by teaching others.

BugScope

A final example of interactive learning enabled by information technology is the use of remote instrumentation. For instance, the BugScope project (http://bugscope.beckman.uiuc.edu) at the University of Illinois makes a scanning electron microscope available to users worldwide. Such use affords a number of advantages. An expensive item of equipment that an institution cannot afford, for example, can be made accessible to its students via the Web. Moreover, such equipment can be made accessible on a 24 x 7 basis, thereby decreasing its unit cost per user. This suggests that "buying cooperatives" can be organized to distribute costs across multiple sites.

Skeptics argue that the tactile "feel" of operating such equipment is an important part of the learning experience—that it is important to gain a sense of how to properly manipulate devices. Haptic feedback, however, can be incorporated into such devices and transmitted across the Internet; some experiments are already being conducted with this technology. Perhaps the most important aspect of this type of work is that it affords students chances to collect, generate, and analyze their own data. Learner-constructed, sense-making experiences consistently are found to be key to improved learning. This example also illustrates how environments initially constructed for one level (university students) may find use at other levels (middle and secondary school students).

The Emerging Cyberinfrastructure and New Experiments

The examples above illustrate how an emergent cyberinfrastructure is already benefiting education. When fully developed, cyberinfrastructure will provide a suite of enabling tools essential to the study of complex systems and to the modeling of real-world behaviors of these systems for learning purposes. It will include software to support collaboratories, visualization tools, data-mining capacity, and data management techniques, as well as support for geographically distributed sensing systems and observation sites that generate enormous amounts of data. This data can be assimilated and interpreted using knowledge representation and manipulation software—for research or instruction.

Furthermore, cyberinfrastructure will permit the "instrumenting" of the learning environment that will enable us to "see" into the classroom and to examine the pathways by which students explore ideas and acquire mastery of material—individually and collectively. The educational context opens up new challenges and new areas of research for the designers of cyberinfrastructure and other cybertools; these tools, in turn, can generate new research questions. Cyberinfrastructure also permits investigators to deal with the enormous data sets created by multimedia observations of classrooms, individual student learning, and scientific observations. Below are some early-stage examples that offer great promise.

Participatory Simulations

A number of education research groups are exploring participatory simulations—the use of low-cost mobile devices in secondary and middle school settings. For example, Lee McKnight and colleagues[21] are working with the Boston Museum of Science and local high schools in Everett and Malden, Massachusetts, to assess the impact of equipping students with networked wireless devices through which they can engage in simulation experiments. Similar, more extended efforts have been launched at the Concord Consortium under the direction of Bob Tinker[22] and at the University of Michigan under the direction of Elliot Soloway and his research group.[23]

In these projects, the electronic clickers described earlier can be replaced by more sophisticated devices such as handheld computers. These offer interactive, two-way communication. For example, not only can data be gathered through the devices, but, after it is analyzed and manipulated centrally, it can be published back out to the learners for local synthesis (along with further distributed analysis).

Distributed Data Collection

Another instance of distributed data collection is in various 311 call center consolidation experiments such as that taking place in New York City.[24] New York City consolidated 40 call centers and 14 pages of phone numbers into a 311 center that handles more than 30,000 calls each day. The information from calls to the central 311 line serves to provide feedback from the community. For example, question-answer pairs are stored in a database; analysis of their patterns reveals citizen concerns. Moreover, collective citizen knowledge of local conditions of the public civil infrastructure helps inform municipal government of priorities. On the scale of a college or university campus, a similar system could be built to support learning.

3-D Digital Printing

Although 3-D digital printing[25] is still quite expensive, it presents the opportunity to print physical artifacts from high-resolution data files that represent the complete internal geometry and exterior surfaces of objects. As this technology becomes more affordable, access issues can be addressed either by interacting with virtual reconstructions of objects via the Web or by printing out 3-D replicas of objects after downloading the appropriate data files.

Immersive Virtual Reality Experiments

Finally, immersive virtual reality experiments that can support telecollaboration and telepresence are under way. Applications exist in telemedicine, for example. Working examples in this area exist, but they are still quite costly. For example, Brown University researchers are developing interactive diffusion tensor MRI brain visualizations as part of the work being conducted by the National Science Foundation–funded Graphics and Visualization Center.[26] Similar environments that support virtual field experiences are under development.

Significant Research Challenges

As the examples illustrate, cyberinfrastructure can help us teach difficult and important material that requires more sophisticated modeling, simulations, and visualization. It allows us to examine and interact simultaneously with multiple, heterogeneous, dynamic, and nonlinear processes that may also exhibit stochastic and irregular behavior. But many challenges remain.[27]

- Often sophisticated mathematics or other science concepts are buried beneath virtual simulations or animations; for example, approximation algorithms are hidden. If these are not "certified" to be numerically stable and well implemented, then the output of the simulations might be incorrectly calculated and mislead the viewer. Thus even though visually striking learning environments can be rendered, vital implementation issues need attention. Moreover this suggests that the incorporation of "visual counterexamples" might be used to create effective learning opportunities. What are the conditions under which such approaches can be used?
- How is experimental error "faithfully" reproduced? What about artificial error that results from an incorrect choice of an approximation algorithm?
- What is the relationship of virtual or otherwise Web-enabled laboratory environments to the traditional "lab bench" or "wet lab" experience? How can hybrid models be created that marry the best of both worlds? What *is* the "best" of each world?
- What does *effective* mean in the phrase "effective learning environments"? How do we instrument these environments to measure effectiveness? Moreover, what are the conditions for effective use? Are there any generalizable conditions? Learner behavior in the laboratory—physical and virtual—can be tracked and observed with much greater detail (for example, via electronic "footprints") thanks to cyberinfrastructure. How can these data trails be analyzed, and what understanding do they provide?
- Even in virtual or Web-enabled learning environments, there is still a need to create a "wrapper" around the images/animations, the framework of inquiry around the simulation, or the experimental process around the remote manipulation of instrumentation. How will this major faculty development effort be addressed?
- What is the (new) role of the instructor within the learner-centered environment? How is the professional role of the teacher/professor changing? How

must pre- and in-service teacher preparation programs change? What are the implications for faculty development?

- Informal learning settings are also being changed, raising the question, where is the locus (or loci) of learning?
- How does the educational system respond to changing behavioral patterns and technical skills of students who are increasingly more comfortable with IT than teachers? What is the impact on the actual development of new materials, resources, products, and processes? What are the new continuing professional development needs for teachers and faculty?
- Is there a proper "mix" of the analog and digital? If so, what are its features? As more and more senses are recruited to represent phenomena, what cognitive issues come into play when dealing with the interaction of these different inputs in the process of sense making? Is there an optimal use of haptic feedback?

What Will It Take to Succeed?[28]

Significant changes in teaching and learning are possible, particularly when interactive technologies are involved. These changes promise to better engage the Net Generation and the adult learner. But, what will it take to turn the promise into success?

Revisit Your Assumptions

The deep reflection required to convert a course or elements of a course into cyberspace forces a fresh consideration of students' experiences in typical classroom settings. Many faculty shy away from this reexamination. Those who do, however, report that cyberspace or the introduction of technology into their site-based classes can be a transformational and refreshing experience in which they rediscover the source of their original attraction to the academy and renew that commitment in exciting new ways.

As one faculty member put it, "Technology is a giant mirror reflecting back to you your own deepest issues. It challenges you to clarify what you value, to rediscover why you went into teaching in the first place, and to be honest about whether your original hopes have been realized. It also sheds light on how we interact with our students and how they respond to our courses, and [it] forces us to think about the real meaning of community and what it is that a group of people assembled in a single physical space experience and how that compares to what a group of people in cyberspace might experience." This same faculty member went on to say that the real power of technology resides in its ability to help us reassert our basic purposes and values as we seek to translate these fundamental purposes into new media and forms of interaction.

Deeply held values and assumptions that we have not examined for a long time must be revisited—and either affirmed or amended—before we can approach the use of different media for communication and exchange.

Engage Learners

Everyone can and will participate in cyberspace; the ideas will generate ongoing discussion long after the class is over. The very thought process that leads to discovery and understanding in a particular field can be exposed and modeled for students, who can then have an authentic experience within the discipline.

How many teachers take time to assure themselves that every student has truly participated in a classroom setting and that the exchange is meaningful? How often is the exchange simply a set of questions raised by students—sometimes in the form of "Will this be on the exam?"—that are answered by the instructor in the form of a monologue?

Relax Control

While reexamining instruction is good, it can be exhausting and unsettling to faculty who have grown up with a traditional view of faculty roles. Online students may interact with the material or each other at any time day or night. This means that the instructor's time is equally unbounded. In cyberspace, the whole thought process is laid open in the building of understanding through much richer conversation. Students can find material that challenges the faculty member's worldview and expertise; they can uncover stories and research results that the faculty member has never heard about. It can be uncomfortable when the instructor no longer controls the subject matter the students will use.

Return to Core Values

In electronic exchanges, faculty members are free to be experts (for example, a physicist, a biologist, or an historian) and to draw their students into the ways of thinking, examinations of ideas, and forms of proof that are the intellectual basis of a field. In addition, original documents and fresh research data are readily accessible on the Web.

In simple terms, students can *do* history, not just hear someone talk about history; they can do biology, not just talk about other people doing biology. In cyberspace, the instructor has unbounded access to electronic images and texts that open up the full range of historical inquiry, analysis, and interpretation, as well as access to contemporary material.

The instructor can model intellectual work, exposing through electronic means thought processes and realities—the blind alleys and sudden bursts of clarity—that we all experience in our search for understanding. For many, this is unnerving; control is lost over both the interaction and the material. For others, it is a true liberation. For everyone, however, it can provide a much more immediate and authentic experience of inquiry than most classroom interactions can offer.

Reflect on the True Meaning of Learning

We face vexing questions today as we try to define the meaning and purpose of an undergraduate education, the nature and goals of graduate education, and the nature of faculty work.

- What do we need to know and be able to do with what we know?
- Is the very nature of the production of knowledge changing? How can we be sure that we are basing our actions on valid understanding?
- If the university and the disciplines are no longer the sole source of discovery, interpretation, and validation, how will we know "truth," and who will have the authority to declare that a particular form of knowledge is valid?
- What do we learn alone without interactions with others? Is this self-study different from what we learn as members of a community? Does it matter whether that community is bounded by a specific location or sense of place or placed in cyberspace?
- Will electronically facilitated interactions—in the absence of personal experience and knowledge of each other—promote a new kind of "unconnected" learning? If so, what difference will this make in the development of practitioners, citizens, and scholars?

The most important gift of liberal learning is the nurturing of a prepared mind, a deep sense of social responsibility, and a commitment to the importance of citizenship in a community of others. Can this kind of "virtuous learning" occur through virtual encounters in cyberspace? Are there other ways to accomplish the same integration of cognitive, social, and emotional development that occur now in face-to-face encounters with others? In cyberspace, can we foster some of the fundamental qualities of a prepared mind, such as

- the ability to learn, not just to memorize the rules of a particular task but to be able to discern or discover what the rules are or should be from a study of situations that are unfamiliar to us;
- the ability to recognize when we do know something and when we don't;
- the capacity to make sense out of an infinite world of images, assertions, words, and "facts," as well as act responsibly and wisely on that knowledge; and
- the ability to apply knowledge resourcefully and ethically.

Model the Highest Standards

In our direct and recorded electronic interactions with students, as educators we must be mindful of our duty to set good examples of what it means to be truly educated, to be responsible learners, to reflect in our ideas and our interactions with others the values of a liberal education, and to be models of integrity. Whether we like it or not, the record of our exchanges in cyberspace reveal a great deal about us. In many ways, technology can both deepen and clarify our educational aims and help us further them. Technology, appropriately used to enhance and expand the scope of educational experience, can enrich our intellectual lives and offer our students an authentic route to discovery.

The most powerful effect of cyberexperience may not manifest in the things people do on the Web or with broadband communication, but rather in how they think and in what they expect from education. People who innovate and create in cyberspace likely will not sit still for a lecture.

Endnotes

1. Consortium for School Networking (CSN), *Digital Divide Leadership* (Washington, D.C.: Consortium for School Networking, 2004), <http://www.cosn.org/resources/grunwald/digital_leadership_divide.pdf>.
2. Douglas Levin and Sousan Arafeh, "The Digital Disconnect: The Widening Gap Between Internet-Savvy Students and Their Schools" (Washington, D.C.: Pew Internet & American Life Project, August 14, 2002), <http://www.pewinternet.org/report_display.asp?r=67>.
3. National Research Council, Institute of Medicine, *Engaging Schools: Fostering High School Students' Motivation to Learn* (Washington, D.C.: National Academies Press, 2004), p. ix, <http://books.nap.edu/catalog/10421.html>.

4. Ibid., p. 2.

5. Ibid., p. 3.

6. Kenneth C. Green, *2004 Campus Computing Survey* (Encinco, Calif.: Campus Computing Project, 2004), <http://www.campuscomputing.net/>.

7. Steve Jones at el., “The Internet Goes to College: How Students Are Living in the Future with Today’s Technology” (Washington, D.C.: Pew Internet & American Life Project, September 15, 2002), <http://www.pewinternet.org/reports/toc.asp?Report=71>.

8. National Research Council, *How People Learn: Brain, Mind, Experience, and School: Expanded Edition,* John D. Bransford, Ann L. Brown, and Rodney R. Cocking, eds. (Washington, D.C.: National Academies Press, 2000), <http://www.nap.edu/catalog/9853.html>.

9. WiMAX Forum, <http://www.wimaxforum.org/>.

10. Edward L. Ayers, “Technological Revolutions I Have Known,” in *Computing in the Social Sciences and Humanities,* Orville Vernon Burton, ed. (Urbana, Ill.: University of Illinois Press, 2002), p. 24.

11. Ibid., p. 24.

12. Ibid., p. 24.

13. Ibid., p. 25.

14. For a discussion of the assessment of scholarship, see Charles E. Glassick, Mary Taylor Huber, and Gene I. Maeroff, *Scholarship Assessed: Evaluation of the Professoriate* (San Francisco: Jossey-Bass, 1997).

15. Ayers, op. cit., p. 27.

16. See (a) <http://www.smartmoney.com/marketmap/?nav=hp_marketmap> for an interesting nonacademic example of an image database; and (b) <http://www.nsdl.org/collection/ataglance/browseBySubject.html> to view a digital library’s collection holdings by content domains.

17. See <http://java.sun.com/applets/jdk/1.1/demo/SortDemo/index.html>.

18. See <http://www.foundationcoalition.org/home/keycomponents/concept/introduction.html>.

19. See <http://mazur-www.harvard.edu/news.php?area=8>.

20. See <http://www.einstruction.com/>.

21. See <http://www.wirelessgrids.net/>.

22. See <http://www.concord.org/research/handhelds.html>.

23. See <http://www.techworthy.com/Laptop/January2004/Handhelds-With-Class.htm?Page=1>.

24. See <http://www.govtech.net/?pg=magazine/story&id=91038&issue=8:2004>.

25. See <http://kmoddl.library.cornell.edu/about6.php>.

26. See <http://graphics.cs.brown.edu/research/sciviz/brain/brain.html>.

27. Funding of course remains a constant challenge. It is necessary to support not only the building out of the physical information technology infrastructure (especially in the face of continued evolution of technology), but also critical faculty development needs. This condition has been reported on in greater depth elsewhere, along with calls for a corresponding shift in culture that rewards efforts and innovation in the scholarship of bringing innovative educational technologies to bear on the classroom. It should be noted, however, that not all solutions are necessarily expensive ones (for example, the use of low-cost electronic clickers described above), and access and equity issues remain.

28. Material adapted from Judith A. Ramaley, "Technology as a Mirror," *Liberal Education,* vol. 87, no. 3 (summer 2001), pp. 46–53.

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