New Learning Environments for the 21st Century:

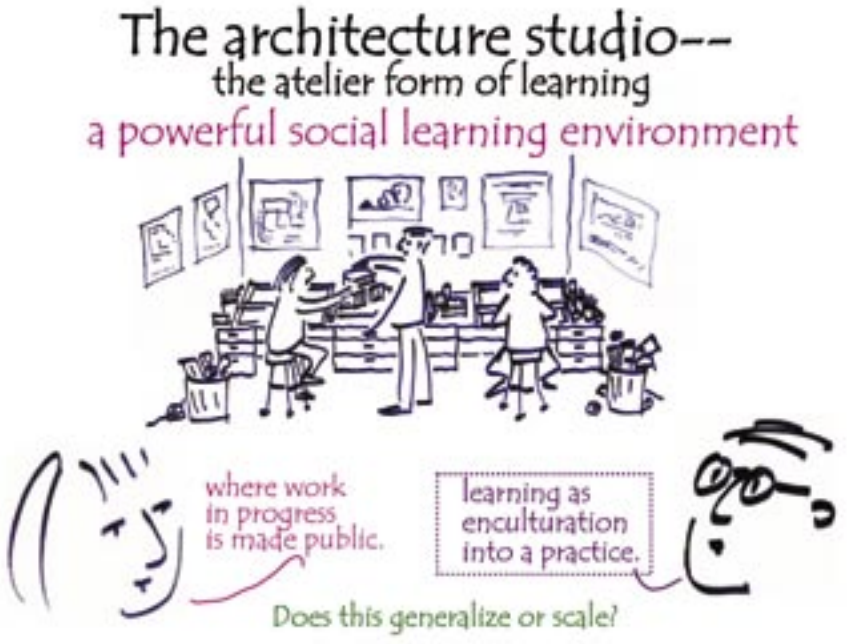
EXPLORING THE EDGE

By John Seely Brown

Even those of us who haven't been teaching very long don't have to be told that today's college students engage with the world differently than we did when we were in school. Today's students are comfortable satisfying their immense curiosity on their own. This capacity for independent learning is essential to their future well-being, since they are likely to have multiple careers and will need to continually learn new skills they were not taught in college. Our students will need to feel comfortable working in cross-disciplinary teams that encompass multiple ways of knowing. These challenges require that we re-conceptualize parts of our educational system and at the same time find ways to reinforce learning outside of formal schooling.

Luckily, successful models of teaching and learning already exist that we could emulate and build on. In the architecture studio, for example, all work in progress is made public. As a consequence, every student can see what every other student is doing; every student witnesses the strategies that others use to develop their designs. And there is public critique, typically by the master and perhaps several outside practitioners. The students not only hear each other's critiques, but because they were in some sense peripheral participants in the evolution of each other's work, they also have a moderately nuanced understanding of the design choices and constraints that led to the final result. As a result, the critique has substantial significance for them all—not just for the student whose project is under review.

Now compare the efficiency of the professor's use of time in this situation with that in a typical office hour. Also consider how students in studios start to



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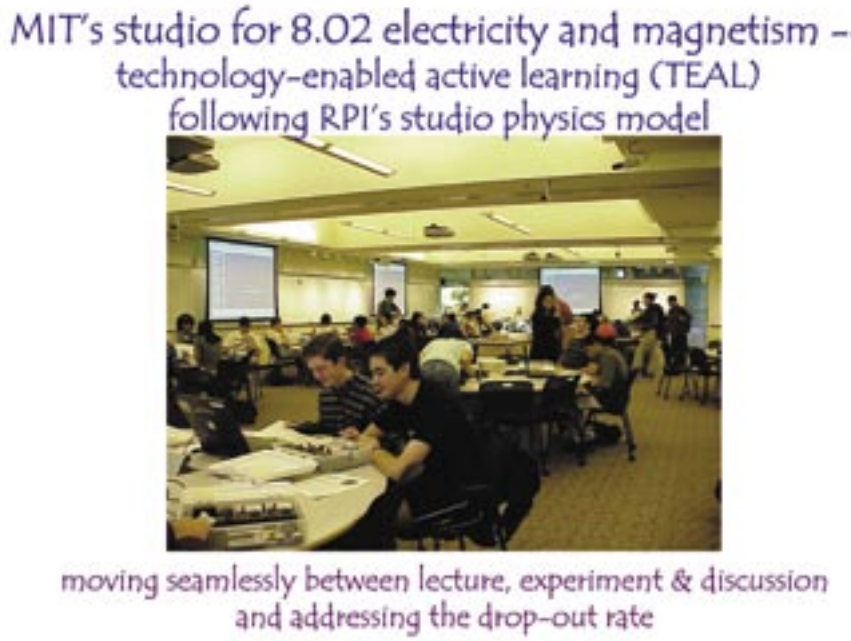


pick up skills from each other; how they witness the wide variety of approaches to a design problem; and how they start to appreciate and learn from the struggles, the missteps, and the successes of their peers. Think about how they start to practice the social and intellectual skills that enable them collectively to become a reflective practicum. They are, in short, becoming acculturated into the practice of architecture.

Another current model worth emulating: the Technology Enhanced Active Learning (TEAL) project at the Massachusetts Institute of Technology (MIT), created by John Belcher, a professor of physics who was concerned with the low attendance and high attrition rates in his department's electricity and magnetism course. This course used to be very efficient at convincing most students who thought they wanted to become physicists or engineers that the grass might be greener elsewhere. So Professor Belcher set out to build a studio for learning about electricity and magnetism—a bold move, considering how theoretical this subject matter tends to be. A subject that traffics in field equations expressed as partial differential equations does not lend itself to intuitive mental models.

Based on a studio physics course at Rensselaer Polytechnic Institute, the TEAL classroom originally had 13 tables with nine students per table. Most of the students' work involved building, running, and experimenting with simulation models and then solving problems. Although there was some recitation, there was no real lecturing. Instead, the professor and teaching assistants walked from table to table, looked at what interesting issues were unfolding, and occasionally interrupted the entire studio to discuss some glitch a particular table had encountered.

The model didn't work as well as Belcher had hoped. After the second year, he and his team began to realize that while they were all skilled at lecturing to 800 people, new teaching practices were required for this new kind of learning environment. Toward this end, they held a summer workshop to help faculty understand how to be successful mentors in a studio—for instance, how to produce activity-based learning rather than lecturing. From the workshop, a new set of practices started to emerge, and the course was redesigned using and perfecting these new practices. Assessment research on TEAL has shown that students who study in the TEAL format significantly improve their conceptual understanding of the various complex phenomena associated with electromagnetism—with the net gain of the low-achieving students being the highest (Dori & Belcher, 2004). Because of its success, the TEAL studio model now has been extended to all of MIT's freshman physics courses and has influenced teaching and learning practices in other departments at MIT. For example, the business school has built an interactive learning space in a new building to support this technology-enabled pedagogy.

Learning to Be

If you look at the learning outcomes for the architecture studio and Professor Belcher's physic classes, it is evident that in both environments, students move from "learning about" something to "learning to be" something—a crucial distinction. Lecturing can be a very effective way of communicating information about physics, but it is often not until graduate school that a student becomes an apprentice and learns what

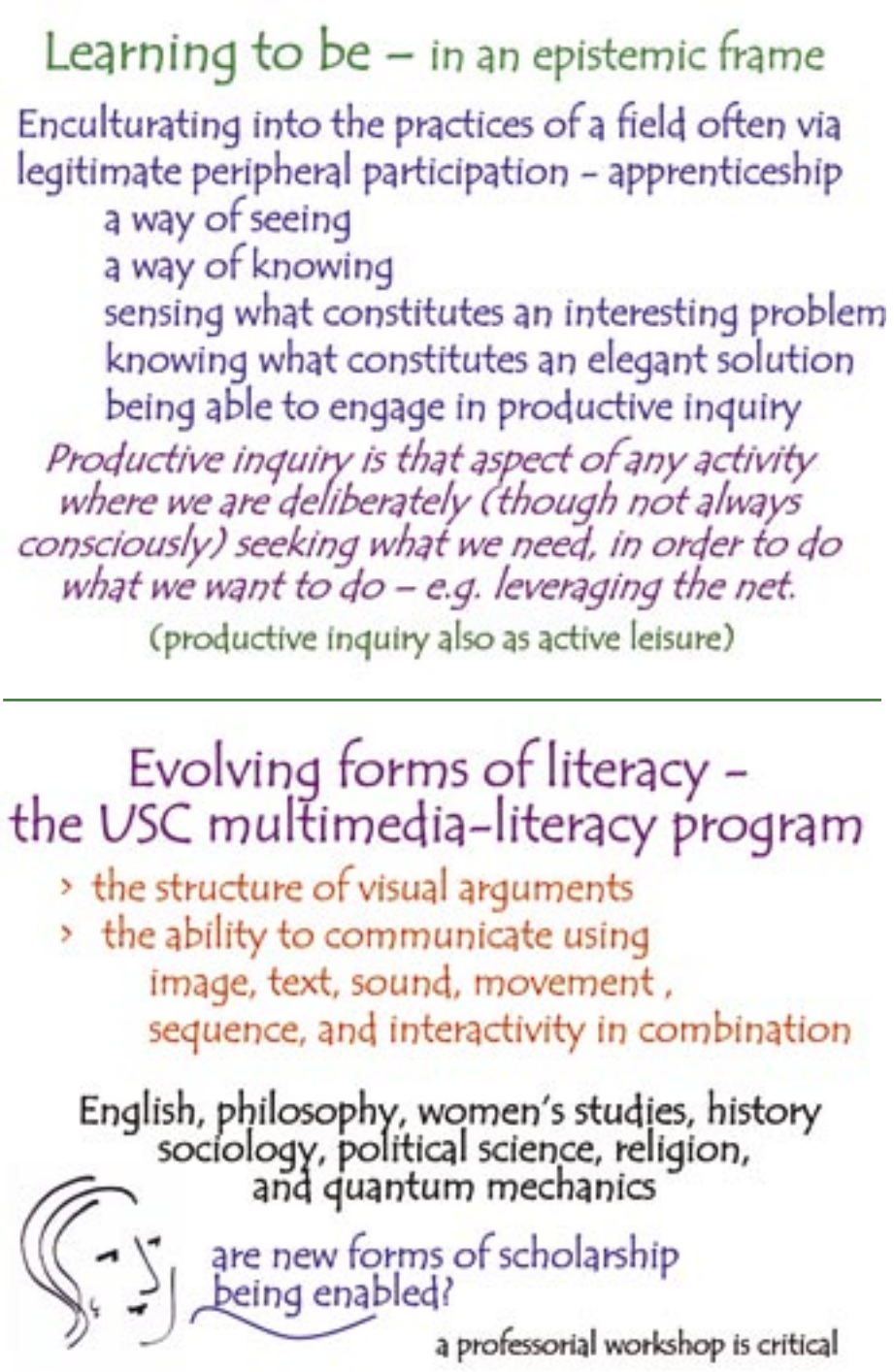
it means to be a physicist or a mathematician or a humanist.

I was a second-year graduate student in mathematics at the University of Michigan taking a course from Professor Paul Halmos when I got my first glimpse of what it meant to be a mathematician. Somebody in our class asked him a question that he couldn't immediately answer, and we all had the chance to watch him struggle with it. He was doing mathematical research; he was exhibiting the practice of being a mathematician. I had spent six years studying theoretical mathematics and had never had the slightest glimpse of what it meant to be a practicing research mathematician. That one moment gave me that insight. I was spellbound.

We need more of such spellbinding moments. We have to find ways for our students to "learn to be" much earlier in their educations. Today's students want to create and learn at the same time. They want to put content to use immediately. They want knowledge that is situated and able to be acted on—all aspects of learning to be, an identity-forming activity. By proceeding along this path, a student bridges the gap between knowledge and knowing.

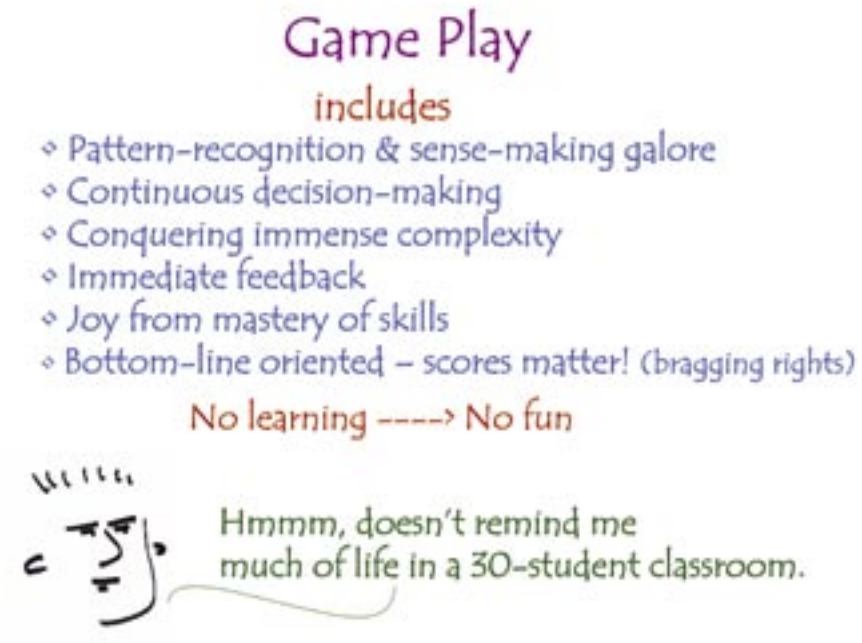
Jean Lave's theory of situated cognition focuses on learning as enculturation into a practice, often through the process of "legitimate peripheral participation" in a laboratory, studio, or workplace setting. Although this term is often thought of as equivalent to apprenticeship learning, it is a more general concept. In an apprenticeship, the student is there to learn a practice under a master who, if he or she is good, has carefully meted out a set of increasingly challenging activities for the student to perform. In peripheral participation the student is engaged in real work, fully participating in the technical and social interchanges. He or she is able not only to learn to do the job, but also to pick up, as though through osmosis, the sensibilities, beliefs, and idiosyncrasies of the particular community of practice. Learning happens seamlessly as part of an enculturation process as the learner moves from the periphery to a more central position in the community.

Needless to say, each community is itself embedded in a broader epistemic frame (a term coined by David Williamson Shaffer), which suggests what problems are considered interesting, what an elegant solution is like, what warrants are acceptable in an argument, and so forth. The frame is often only implicit, but being in a community of practice enables the learner to intuit and embody it. Underlying this all is the notion of engaging in productive inquiry, that aspect of any activity in which we deliberately seek what we need in order to do what we want to do.



Learning to Speak Digital

We now have tools and resources for engaging in productive inquiry and learning that we never had before. In today's Internet environment, learning to be literate in multiple media is an important tool in learning to be. When we're looking at new ways to teach, faculty must understand how to foster this new literacy. In doing so, it helps to understand the new vernacular of students who grew up digital. Much of the language is derived from film. Digital natives are interested in how cuts function, how montages create emotional tension, and how flashbacks and nonlinear narratives can fold into linear time. There is also a language of interactivity that comes from the game world, especially



from the massive, multiplayer role-playing games.

In addition, our digitally literate students (and hence we) also must learn the skill of navigation. They develop, in a way, a sense of smell—they can sniff their way through the Web at blinding speed. They have an intuitive knack for locating resources within the vast reaches of the Internet that those of us who speak digital as a second language labor to find—a skill that serves them well in the context of productive inquiry.

All of these components come together to enable rich immersive, interactive genres that can be extremely expressive. In a conversation between George Lucas and Elizabeth Daley in the provost's office at the University of Southern California (USC), Lucas succinctly described the nature of this new literacy: "To tell a story now means grasping a new kind of language, which includes understanding how graphics, color, lines, music and words combine to convey meaning."

Daley (and USC more generally) followed up on this insight by creating an Institute of Multimedia Literacy to experiment with how to provide both students and faculty the chance to develop these new literacy skills. The program has touched nearly every department at the university, including women's studies, political science, religion, and even a course in quantum mechanics. Its purpose is not to teach about the tools of multimedia but rather to focus on new expressive practices enabled by these tools. For example, we all know how to make arguments in text, but how should we make an argument visually? More generally, how can we communicate effectively using image, text, sound, movement, sequence, and interactivity? Such skills are crucial today, given how challenging it has become to capture and hold someone's attention.

The success of this program has been due, in part, to a two-week summer workshop that professors who want to be a part of the institute's program must take. As in MIT's studio-based learning efforts, it is of critical importance that professors and their teaching assistants experiment ahead of time with the medium, since a key part of using the tools of the institute in a course is that students must "write" their final papers in multiple media and publicly present them. Another aspect of the workshop is that the faculty bring along course syllabi and engage in something like storyboarding to get a sense of the flow of the course content, as well as what kinds of multimedia assignments make sense and how to stage them. Reflecting on courses from this point of view leads to some provocative discussions among the faculty in the workshop.

Learning to Teach Digital Natives

In addition to learning the digital vernacular, it is important that faculty address some key questions about today's college-age students. How do they learn? How do they like to learn? How do they solve problems? And most importantly, what creates meaning for them and helps them to construct their sense of self? One way to answer these questions is by looking at video and computer games. The first thing you realize is that most video games are incredibly difficult to master. If you're not extremely good at pattern recognition, sense-making in confusing environments, and multitasking—and if you're afraid to constantly explore and push the limits—then you won't do well in the game world. In this world you immerse yourself in an immensely complex, information-rich, dynamic environment where you must sense, infer, decide, and act quickly. When you fail, you must learn from that failure and try again and again and again. Continuous decision-making in conditions of uncertainty is the essential skill.

In addition, the gaming generation turns out to very bottom-line oriented. They want their performance to be measured. They want to learn and, without metrics, they can't tell if and how much they are learning. Surprising as it may sound, many gamers say that if they're not learning, it isn't fun! It turns out that using excellent pedagogical principles in constructing a game—for instance, requiring that players tackle challenges that get increasingly more demanding, but at just the right pace—makes for great play. So game designers must know how to design good learning environments.

The more I study computer games, the more I think about the term "serious play." A story about a 16-year-old boy named Colin might help explain what I mean. His dad was trying to convince him to take his history lessons about Rome more seriously. Colin's knee-jerk reaction was, "I don't want to study Rome. Heck, I build Rome every day in my online Cesar 3 game" (or it could have been Civilization 3). Then Colin and his dad started talking about class in our society. About halfway through the conversation the dad stopped and asked Colin, "What does class mean to you?" Colin thought for a moment and said, "You know, in Rome, your class was reflected by how close you lived to the Senate" (only somewhat true). "I think today in the United States it probably reflects how close you are to a senator." Clearly Colin is forming some

kind of model of the social dynamics in both Rome and today. At a minimum, he is engaged in pattern recognition and sense-making and is willing to apply those patterns to novel situations or questions.

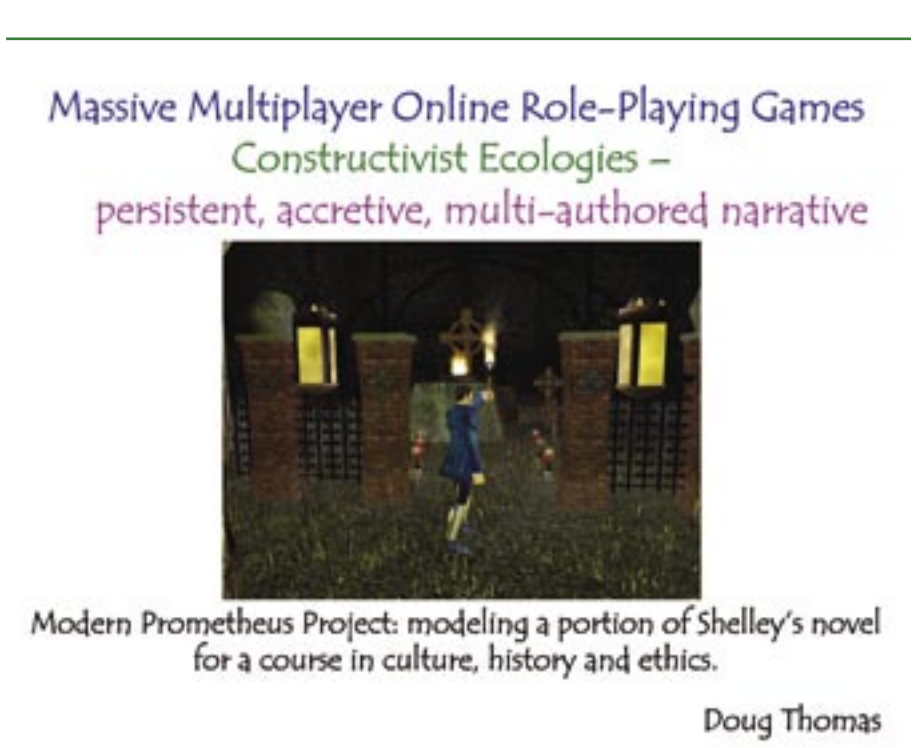
Let's look at World of Warcraft, one of the most popular online multiplayer role-playing games in the world. (The morning it was released in Beijing, 150,000 kids lined up outside to get it. Now, a year later, there are over 4.5 million players). Those who aspire to become guild leaders must build a guild, and those who don't must join one, since nearly all of the quests that players go on to become more powerful and to build up rank (remember in games, everything is measured) require multiple players. Quests are complex, require careful planning and training, and require amazing skill across a variety of roles. A high-level quest cannot be carried out by just warriors, for example. Healers and spell-casters are also needed, and all these players must function as a well-organized and practiced team or a complex quest won't be successful. So to build a guild, you must be able to attract, train, and retain other players to be part of it.

I've now had the chance to study several of the best guild masters in the World of Warcraft and to explore the leadership skills that are necessary to being a guild leader. Stephen Gillett, one of the people I interviewed and watched, told me that guild leaders must create a vision and a set of values that attract other players. Next, they must find, evaluate, and recruit players who have a diverse set of skills that fit with the quest's goals. Then they have to create an apprenticeship program to train new people very quickly. Next they have to orchestrate group strategies for the quest. But the biggest challenge is to keep the guild running. To do this, they have to create, sell, and adhere to the governing principles of the guild and to adjudicate disputes and find equitable ways to split up the spoils of any successful quest. Since there can be as many as 40 people on a given quest, they may even need to persuade another guild to join forces.

Isn't this the skill set that a CEO, the creator of a startup company, or the leader of a non-profit organization needs to have? People who write about game play seldom talk about the social life around the edge of the game, but here is where most of the thinking, planning, trading of arcane bits of knowledge, and learning actually transpire. Stephen has a very senior management role in one of the largest Internet companies in the Bay area, and he attributes his meteoric rise in management to the skills he learned in game play. Of course, one case hardly proves the rule, but the more I probe, the more I believe that his story is not all that unusual.

These games were not designed to be vehicles for learning; the kind of learning that Colin and Stephen experienced is an accidental effect of the game. Might it be possible to create games whose primary aim is to enhance this kind of learning? Note we are not talking about games designed to teach something explicitly but rather games the playing of which results in the development of useful social, technical, or managerial skills.

Douglas Thomas at the Annenberg School of Communication at USC is currently designing such a multiple-player role-playing game, called Modern Prometheus. But unlike World of



Warcraft, this game is designed to be a classroom: His course in culture, history, and ethics, based on Mary Shelley's novel *Frankenstein*, will he held in the game space. In it, students will experience ethical dilemmas that emerge as unintended consequences of the decisions they make in playing the game. Each decision either opens up or closes off later choices in the game. Students can better understand the complexities of ethical judgment and better evaluate the choices they make if they see the effects of those choices. They can also play a variety of roles, which allows them to identify with different perspectives and experience directly how each set of choices affects a variety of people.

Learning to Network

Since, as the previous examples suggest, learning can be a powerfully social act, there are ways to blur the distinction between formal and informal learning. In the networked age, communities organize themselves around the Internet, forming their own distributed learning milieus. A kind of learning to be emerges from joining and becoming a full participant in a community of practice, which requires the participant to assimilate the sensibilities and ways of seeing the world embodied in that community.

This is also what happens when someone joins an open-source community. Although each has its own unique constitution and style of working, nearly all of them have certain key practices in common. For example, code is written so that it can be read, improved upon, and extended by others and is thoroughly tested by the creator before being submitted to the community. New members nearly always begin by writing and patching non-kernel code. Having made enough contributions that are robust, useful, and done in the style of the community, neophytes are eventually allowed to make contributions to the kernel operating system code—a real achievement. That is how they become recognized as key members of the community.

This process trains thousands of participants about good software practices. Said differently, what has emerged is a powerful "distributed cognitive apprenticeship" that functions across the world. Today there are about one million people engaged in developing and refining open-source products, and nearly all are improving their skills by being part of these networked communities. The key to learning here is that all contributions are subject to scrutiny, comment, and improvement by others. And there is social pressure to take the feedback seriously. Although there is no formal credentialing process, it informally exists. Being asked to join the governing council of an open-source community or to oversee what code gets accepted and installed in the kernel of an open-source system is the mark of an advanced practitioner.

Compare this to traditional academic training in computer science. In my own education, those of us who could tried to write "clever" code—code that was so mysteriously and compactly written that very few could figure it out. Although we often learned from each other, there were certainly no mechanisms that supported the social aspects of learning, and it never felt as though we were joining a learning community. The open-source movement has changed this and transformed how many people learn to be computer professionals. Furthermore, this "openly share and improve as a community of practice" principle has been applied broadly in education to transform learning and teaching in various ways (Iiyoshi, 2005).

Demand-Pull Learning

In the 20th century, the approach to education was to focus on learning-about and to build stocks of knowledge and some cognitive skills in the student that would be deployed later in appropriate situations. This approach to education worked well in a relatively stable, slowly changing world where a student could expect to use one set of skills throughout life. But the concept of lifelong learning—a term used all too glibly—is now more important than ever. When technical jobs change, we can no longer send a person back to school to be re-trained or to learn a new profession, because by the time the formal educational process is completed, the domain is apt to have morphed yet again. A different approach is called for, an approach suggestively called a "demand-pull" rather than the traditional "supply-push" strategy. In the new approach, the focus in education moves from building up stocks of knowledge (learning-about) to enabling students to participate in flows of action, where the focus is on learning to be through enculturation and on collateral learning.

This is Dewey for the digital age: a profoundly social construction of understanding enabled by the Internet. The demand-pull approach draws students into a rich (sometimes virtual) learning community built around a practice. It is passion-based learning, intrinsically motivated by either wanting to become a member of that community of practice or just wanting to learn about, make, or perform something. Formal or informal, learning happens in part through a kind of reflective

practicum, but here the reflection comes from being embedded in a social milieu supported by both a physical and virtual presence and inhabited by both amateurs and professionals.

A demand-pull approach to learning seems to be extremely resource intensive. After all, lecture halls that handle 800 students correspond to an industrial model of efficiency, the goal of supply-push. The demand-pull form has no such streamlined equivalent; its efficiencies come from the degree to which participants educate themselves and each other, as they carry out studio-based practica.

The Internet is quickly becoming a vast resource for supporting demand-based learning, and there is a rapidly growing amount of open courseware. A number of powerful instruments and simulation models running on super-computers also now exist that can be remotely accessed by learning communities both in and out of school. Social software enables communities to form and find each other, to learn through remixing, tinkering, and sharing artifacts using the rich media now available. Multiplayer game platforms are becoming interesting experimental platforms for the social sciences, open to anyone who wants to participate. In the arts, we have digital movie-making, digital photography, and music-making with programs such as Garage Band. What we end up with is a vast and relatively unexplored "learning-scape." This is a new kind of experiential learning or an experiential medium for learning through participation.

Suppose we consider a hybrid model of learning wherein we combine the power of passion-based participation in niche communities of practice, with a limited core curriculum for teaching the rigorous thinking and argumentation specific to a particular field. (Designing such a core would require an elegant minimalism.) With the nearly infinite number of niche communities that exist on the Internet, it is reasonable to expect any student of any age to find something that he or she is passionate about. For middle- and high-school students, finding and joining such communities might happen outside of formal schooling and might actually become a new role for public libraries. College students might join such communities through their own or another institution. We might also see learning that begins in one community but then branches as students develop interests and skills, thus weaving a tapestry of niche communities of interest and core curricula. Each community would help ground and complement the others. Such an experience would certainly be a great foundation for lifelong learning in a world of accelerating change.

Resources

- Dori, Y. J. & Belcher, J. (2004). "How Does Technology-Enabled Active Learning Affect Undergraduate Students' Understanding of Electromagnetism Concepts?" *The Journal of Learning Science*.
- Iiyoshi, T. (2005) "Opportunity is Knocking: Will Education Open the Door?" *Carnegie Perspectives* at http://www.carnegiefoundation.org/perspectives/sub.asp?key=245&subkey=115
- Shaffer, D.W. (2005). "Epistemic Games." *Innovate*, 1(6).

Web Resources

- For a case study of MIT Professor of Physics John Belcher's course-transformation efforts, see: http://cases.carnegiefoundation.org/kml/KEEP/belcher1/index.html
- See also the Web site for the MIT electricity and magnetism course redesigned by Belcher (part of MIT OpenCourseWare): http://web.mit.edu/8.02t/www
- For information on studio physics, see http://web.mit.edu/8.02t/www/802TEAL3D/teal_tour.htm
- For the TEAL project Web site, see: http://icampus.mit.edu/projects/TEAL.shtml