Evolving a Distributed Learning Community

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Abstract

Technology can extend traditional teacher/learner relationships beyond the space/time limitations of the brick and mortar classroom. And it can challenge and redefine how teachers and learners have related since antiquity. This chapter describes the evolution of a course in which traditional relationships have been and are being challenged, via internet and television, in pursuit of the elusive potential of a fully distributed global community of empowered learners.

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I am pleased to announce that the course described in this paper won the $25,000 Paul Allen Foundation Distance Education Competition.

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The distributed learning community described in this paper continues to evolve and has progressed well beyond what is described in this paper. The biggest technical improvement resulted from displacing static html pages with dynamic pages generated on the fly for each student by a comprehensive coordination technology for teaching and taking web-based courses. This is currently based on Perl and CGI but is transitioning to rely on Java, CORBA and Authorware. What was once one course has turned into several and other faculty are starting to introduce similar courses.

Introduction

I am not an educator by training. My graduate and postgraduate work was in theoretical and experimental neurophysiology and my career was as an software engineer, building compilers and libraries for an object-oriented programming language called Objective-C. The experience led to a growing awareness of the distinction between *evolution* and *design* that brought me from industry to academia to work on these ideas with the Program on Social and Organizational Learning at George Mason University.

The course to be described here, Taming the Electronic Frontier [Cox1] is my vehicle for elaborating evolutionary methods of organizational learning in practice. I'll describe how this course is taught today, how it evolved to its present state, and how it may evolve from here. This will illuminate the point to be developed in the next section. Human institutions in general, and this course in particular, are part of an evolutionary process that defies prediction, control and design.

Industrial Age Concepts, Terminology and Deeds

The little red schoolhouse of our parents era and today's schools were defined and produced by the age of manufacturing. This now-established paradigm is shifting to a new age of information. Such shifts do far more than parachute newfangled whizbangs into established institutions, paradigms, and power relationships. They challenge and reinvent the institutions, paradigms, and power relationships themselves.

The manufacturing age's infatuation with central planning and design is still very much with us today. Engineers, scientists, politicians, managers, and educational theorists still speak as if we can, should and therefore *must* design unimaginably complicated human systems as if they were steam engines or automobiles, manipulating them externally as if the designer were not an integral component of the human process that produces them. But what actually governs complex systems is rarely the industrial age's notion of design at all. Rather, they *evolve.*, shaped by an interaction in which system and environment minutely adjust to each other as biological organisms evolve within ecologies.

In the book *Bionomics: Economy as Ecosystem*, [Rothschild] argues that the urge to emphasize design at the expense of evolution is a symptom of the pervasive influence of the industrial age on our language, thoughts and deeds. For example, when we're told that the fed wants to "put the brakes" on an "overheating" economy, someone is speaking of a vast ecological system of flesh and blood people as if people were somehow like machines.

This causes malignancies far more serious than language. This language invites listeners to believe that the government actually understands an unimaginably complex economy and is therefore competent to control it without doing more harm than good. Rothschild argues that this might be countered by applying the same language that we use for biological systems for economies. After all, aren't economies, firms, universities and classes living biological systems too? Don't they evolve exactly as giraffes, forests or coral reefs do, without the designing and controlling hand of an omnipotent nerd? And mightn't the new terminology foster the caution that we feel when engineers propose to intervene in marshes, rain forests, deserts or oceans?

This chapter will describe how industrial age conceptions of the educational process are being challenged by this course, such as the understanding that decision-making power resides solely in the instructor or that students are present in the same classroom or even on the same continent and time zone. I'll leave it to the reader to note and reflect on these implications in context. Here I'll describe why we should move beyond the industrial age conception that instructors *design* courses to an new conception in which *evolution* plays the dominant role.

In *Instructional Design For CMC In The K-12 Environment*, [Eastmond] elaborates a design process in which educators prepare instruction for learners as a sequence of discrete steps: analysis, planning, design, development, implementation, and evaluation. This is exactly the same waterfall model that dominated software engineering literature in the 1970s inspired by the same industrial age faith in design.

The waterfall model was displaced by rapid prototyping when software customers rose in revolt to a model that virtually excludes customers from the decision-making process. The difference is not in the individual atomic steps, for the same steps are just repeated more than once. This repetition is what includes the customer in the decision-making power elite. This is a political difference, not a technical one, for it expands the power circle to recognize that the customer has a valid role to play in design.

Taming the Electronic Frontier

The course to be described here is also a living, evolving system that belies the presumptions of its "designer". It originated four years ago as a traditional brick and mortar class but soon evolved into a entirely electronic format that was neither imagined nor imaginable when I "designed" it.

The course originated from a straightforward institutional requirement. The MA in Telecommunications Program needed a new core course to introduce computer-based communication to their students. No existing courses were quite suitable because they either focused too narrowly, on technology alone, or too broadly, on humanities with no focus on technical skill development.

The resulting course draws a diverse mixture of computer novices and technical sophisticates. It introduces both

sides to the techno-centric and human-centric issues (content and social) that are unfolding on the electronic frontier. It is heavily interdisciplinary in order to help technical and non-technical students to confront the cultural chasm between classical and romantic ways of understanding [Pirsig].

Television

We initiated the class in a traditional brick and mortar electronic classroom. But the mismatch between this initial design and the needs of its students were soon apparent. Most (95%) of the MA in Telecom Program's students hold full-time jobs. which made it difficult for them to take time off from work. Traffic congestion and parking shortages are endemic problems. An informal survey showed that the majority are mature individuals with families and jobs who are capable of considerable responsibility and autonomy. Nearly all (>90%) owned their own net-capable computers or had access to one at work.

I'll describe the process of evolution and adjustment later in order to first describe how the class is offered today. As of this fall (1995), I teach this class in the GMU TV studio. About a third of the class is present in person, another third attends virtually via local cable TV and via videotapes in the library, and the final third attends from overseas. K12 schoolteachers in the U.S. Dept of Defense Dependents School system (DoDDS) in Germany participate in this class as part of an Advanced Research Projects Agency (ARPA) Computer Aided Educational Technology Initiative (CAETI). We'll be experimenting with overseas delivery of video over the internet starting this spring.

Televised lectures are greatly appreciated by those who can't attend in person. But television is the least important and most expendable and problematic part of our infrastructure. Its bandwidth requirements inhibit the potentially global reach of this course. But most of all, it perpetrates and reinforces the traditional stand and deliver approach to education.

For example, since only the instructor has a microphone and only a minority are present in person, classroom discussions are only marginally useful. Thanks to the TV studio staff and a student project this fall, virtual students will be able to phone in questions and participate in discussions beginning this spring. But real-time discussions aren't possible even in principle for the overseas third of this class because of the six-hour difference in time zone and the delays of delivering videotapes by mail.

Multi-way Learning Channels

Our solution was to keep television until something better can displace it, but to put most of our emphasis on internet's compensating ability to weld students into experiential learning communities. Several such channels can be discerned:

Teacher/Student:

The instructor's primary contribution to the learning process is a sequence of 14 web pages, one for each week of the course. These weekly pages provides announcements, a synopsis of the material to be covered in the lecture, required readings, optional references, and the task assignments for that week. Insofar as copyrights permit it, the readings and references are provided as hotlinks in compliance with the completely electronic theme of this course.

Each semester begins by distributing a single page that instructs the students to throw it away as soon as they manage to locate the same page on the web. Although students can and do print paper copies, this is the last time they need to touch paper in this course. Learning occurs experientially while using computers to perform tasks at home, office, laptop and GMU computer labs. They return homework the same way, via web forms, netnews, email, and ultimately by publishing class work as web pages.

Student/Computer:

Experiential learning occurs in response to a series of twenty tasks assigned in the weekly pages. Since the tasks require the student to use their computer to accomplish some goal, this creates an opportunity for student-computer interaction during which students learn by experiential immersion in the problem domain.

Student/Student:

Anyone familiar with computers will be aware of the frustration of trying to get computers to do the right thing. This is especially critical since students are working from home without an office expert to call on for help. Although a certain amount of frustration is an inevitable and essential part of the experiential learning process, students regularly encounter difficulties that can only surmount by having someone to call for help. Generalized experience isn't sufficient since the problems may range from disk crashes to viruses that require detailed experience with that student's hardware and software. Since I use a Macintosh and have only limited access to Wintel machines, a way to get help to those with machine-specific problems was crucial.

The solution was to mobilize student/student interaction as an integral part of the course. Telephones and email play a role, but the primary channel has been a class-specific newsgroup [News] in which students describe problems, post solutions, and otherwise discuss common interests.

Student/Teacher:

Students return each week's task results electronically by exercising tools as they learn them. As each week's results filter in, I use special-purpose programs, written in Perl, to publish their results back to the web so that they can be accessed via a hotlink in the page that assigned each task.

Since the task results are public information, this creates an additional learning channel through which those having problems can learn from those who've completed the tasks successfully. The public nature of the results pages makes them an unusually powerful channel for teacher/student interaction. For example, I've written my programs to mark incorrect information with an ugly flasher. Since all work is public, singling out incorrect answers, even without explanation, is an powerful way of directing students attention towards problems I want them to fix.

Student/Environment

Although this mode of interaction isn't primarily internet-based, getting students involved as active participants in improving their environment has proved to be a crucial aspect of this course without which the other innovations would have been impossible. I'll discuss this in the section titled "Empowering the Students".

In the beginning...

Four years ago, the technical and institutional infrastructure that supports this course today far more limited than it is today. It may be helpful to review the initial situation here, since every evolutionary step involved surmounting the tightly interrelated chicken versus egg paradoxes of any large institution.

When we began, our most reliable option for teaching this class was a limited number of electronic classrooms with computers and other audiovisual equipment capable of projecting computer-based presentations. Although these classrooms are a welcome improvement over chalk and blackboards, they weren't responsive to students who're unable to attend face to face classes. Expecting students to fight traffic and parking congestion to haul themselves to an electronic classroom seemed like the wrong idea when the same technology could be used to haul the education to student in their homes and offices. But most of all, passively watching audiovisual demonstrations doesn't provide the experimental immersion that students need to apply what they learned outside the classroom.

Another option was to teach this course in a computer laboratory. However GMU's labs are conceived and managed as resources for students with no other access to computers. Students are forbidden to install software there. This made the labs nearly useless for a course that emphasizes software installation and configuration. Until

very recently the software used in this class wasn't even available there, and requests to add it involved extended negotiations with a lab bureaucracy who often viewed this as a threat to its power and prerogatives. Fortunately, this attitude has since changed as I'll describe below.

The final option was the one that we adopted, to mobilize the computer power that the students already had at their homes and offices. But getting them networked involved three years of evolutionary struggle to be summarized below.

Empowering the students...

In his Nobel Prize-winning paper, *The Use of Knowledge in Society,* [Hayek] argued that the power of markets originates from their ability to mobilize the tacit knowledge of all participants. He contrasts this with the inability of central planning bureaus, such as Russia's before its collapse, to gather precise knowledge of abundance, scarcity, preferences and tastes. Although central planners can process formal knowledge effectively, they are unable to collect or process tacit, local, informal and unarticulated knowledge of taste, preferences, scarcity and opportunity as effectively as a fully distributed system of independent decision-making entrepreneurs.

When this class started, it became clear that the bureaucracy was only dimly aware of critical breakdowns such as inadequate dialup line capacity. Furthermore they lacked a meaningful basis for prioritizing limited resources except in response to political clout. By contrast, this was no problem at all for students. By using the system they knew exactly where the crucial breakdowns were and which were the most important. And by surmounting them to succeed in this course, they had discovered precisely how to fix them for others. In other words, a distributed community had access to tacit knowledge that was inaccessible to the central bureaucracy.

However they were missing the institutional permission to step outside of their traditional passive role, become active members of the community and apply this knowledge to improve matters for everyone. To provide them this permission, I originated organizational learning team projects which proved to be so successful they are still a key feature of this class. The instructions are deceptively simple:

1. Organize into teams and choose a team leader and a librarian
2. Pick any breakdown that has annoyed you this semester
3. **Eliminate it** for 30% of your grade in this course.

Although these projects are welcomed throughout the university today, this was by no means clear when we began. I invited our Provost and the head of the lab bureaucracy to the class in which I explained exactly what we were about to try and why in order to obtain their buy-in and support. These exercises were crucial to everything that followed. By mobilizing students as active change agents and not as passive complainers, I multiplied what I could accomplish as faculty by the number of students in each class. Although bureaucracies can easily intimidate individual students, this doesn't work with scores of eager students applying what they've learned to make things better for everyone.

The initial mind set soon crumbled before the onslaught. A few of the old bureaucracy even left. The rest adopted a customer-oriented attitude that views student initiatives as the solution, not the problem. The university as a whole is beginning to consider how students can address breakdowns in other areas. We've even started aiming this powerhouse outside in search of more effective relationships between academia, industry and government.

Evolving the plumbing...

In the first classes, unix-based tools such as pine, tin and lynx were the backbone of this course. But since such tools expose students directly to unix they often encountered problems that can take years to learn how to solve for

themselves. Initially we developed unix tutorials in the organizational learning projects. But we soon concluded that we should be eliminating unix, not documenting it. Newcomers should learn unix when they aspire to expert status and not in their first encounter with computers.

There's a tradeoff here. Terminal emulators are easier to install than the foundation for running internet-based tools. But once the new foundation is running, it supports tools that are so much more satisfying to learn and use that students can learn them unaided. We decided to invest our resources in a one-time effort to get everyone onto a foundation that was easy to use instead of forever struggling to get computer-phobic faculty and students to use unix-based tools effectively.

This became possible when the university purchased site licenses for host software that allows any student to establish an internet connection over the modem lines that they'd otherwise use for terminal emulators. The organizational learning teams soon produced [Cox2], self-installing software for Macintosh and Windows, and documentation and videotapes for installing and using it. This packages has since become the real backbone of this course.

The perennial problem is the frustration new users encounter installing foundation software, configuring modems, and diagnosing telephone problems. The computer labs became part of the solution this fall. Starting in the labs has the advantage that classmates are present to help those who're stuck, and the face to face time helps to build a spirit of community. The first week's experience in the labs also makes the difficulties of parking and commuting sufficiently compelling that students are eager to surmount the frustrations of getting the communication foundation working at home.

Where next? ...

An obvious challenge is to address the demand for continuing education in the work force by expanding this approach to other courses. However very few faculty have the technical skills to prepare their own educational materials for internet delivery. And more critically, they lack the skills needed to get their own students online.

The first five weeks of *Taming the Electronic Frontier* addresses the second need, so we simply offered these five weeks as a mini-course called *Internet Literacy*. Non-technical faculty are encouraged to refer students needing training there. Beginning this spring, we'll broadcast the lectures for this mini-course to dorms and remote classrooms via a newly installed video-on-demand server and fiber optic backbone. We've developed a web-based, automatically-graded Internet Competency Quiz that they can assign to identify students who should take Internet Literacy in order to participate in network-intensive courses effectively.

Although we have no plans to eliminate television in the short run, we expect other technologies to displace it soon. We're especially interested in internet-based white board technologies that can deliver high-quality presentation slides and audio to distributed computers via low-bandwidth (modem) connections. Such technologies focus limited bandwidth on presentations and audio which are clearly essential to learning in ways that a professorial talking head is not.

An new kind of nontraditional student seems to be emerging from the explosive growth of interest in the internet. Local internet access providers see a new market for extended learning communities such as the one we've developed in this course. Starting this spring we've initiated commercial relationships through which internet access providers can sell course seats on a not-for-credit basis. The implications in this era of shrinking state funding are simultaneously disturbing and exciting.

Conclusions

Although the work load is heavy and the experiential learning process frustrating, students regularly report that they learned far more than in traditional classes. This is not due to television but in spite of it. Integrating internet's support for multi-way communication offsets the one-to-many limitations of television. The preconception that "something must be lost" in moving to a distance learning format overlooks the fact that this extends the contact time from hours to days per week, it projects learning opportunities across time and space to learning communities who'd otherwise be inaccessible, and it supports experiential learning modalities that are not feasible in a traditional face to face classroom.

Although the innovations are usually perceived as technological, the actual innovations are technology-enabled pedagogical approaches such as experiential learning in collaborative learning communities. Technology is only the enabler, and no single technology is sufficient on its own. Diverse technologies can be deployed in combination to achieve more than any one can do on its own.

But as the ancient maps used to say, here there be dragons...

Immature Infrastructures:

Today's internet is vastly easier to use than it once was but there is still considerable room for improvement. Substantial technical ability is needed to get a class full of students online, each with slightly different computers, modems, telephone systems, and internet access providers. Although integrated systems such as Netscape now offer email, netnews and web access in a single easy-to-use package, crucial parts of the total system are still missing that require substantial technical ability to surmount. Few instructors are able to author web pages as html documents. Even fewer can develop their own perl programs to transform task results into public documents on the web.

Diverse Learning Styles:

Although we've had considerable success getting technophobic students online, some students have great difficulty with the left-brained way of reasoning that the computer industry takes so much for granted. I routinely use *Zen and the Art of Motorcycle Maintenance; An Inquiry into Values* [Pirsig] as a textbook in order to help both factions recognize and be more understanding of the radical differences between classic vs romantic and techno-centric vs human-centric ways of understanding.

Quality:

Any shift in power from teachers towards students implies tension over differing ideas of quality. I regularly assign a task that instructs students to build an electronic 'product' (a web page) based on what they think their classmates might 'buy'. The grades for this task are assigned by 'selling' the products in an electronic market for peer assessment. I find it intriguing, but troubling, that students often assign high value to products that emphasize flash and glitter at the expense of academic substance. I look forward to refining this task to understand this better than I do now. But in the interim this is a clear caution that a careful balance of power between teacher and student is necessary instead of either extreme.

Cost:

Costs are hard to determine precisely because the television and internet technologies used in this course were already in place. However a realistic cost accounting would show that costs are high indeed. A televised class involves a support crew of three in addition to the instructor, and there are also the fixed and recurring cost of the studio itself.

The costs of internet-based courses are also high. This course has triggered explosive growth in demand for modems, telephone lines, and computer capacity in addition to the technical skills to support them. In this era of shrinking state support for education, it has become clear that the university can never satisfy the demand on the traditional free basis so outsourcing is highly probable.

The cost in my time is hard to gauge precisely. I spend far more of my time on this course than my brick and mortar classes. However most of this time is spent as an investment in building a distributed learning community and infrastructure as part of my research goals. Now that the infrastructure is in place, routine preparation for each week's class is smaller since prior semester's task and weekly pages can generally be reused.

Revenue:

I've alluded to a number of possibilities that might someday offset the higher costs of delivering courses electronically. Even though most of these remain in the future, our administration has thus far been willing to support this investment because enrollments and thus revenues for this course have been consistently higher than other graduate-level classes.

There are many other revenue-related challenges that we've only begun to consider. The most fundamental of these is that electrons aren't confined by the geographical state boundaries so crucial to state funding agencies. Fortunately, web server technology is available to address the superficial problem of revenue collection for courses as unigranular electronic property. The problem is that these issues have not been addressed for the smaller granularity electronic property within courses: articles, books, clip art and computer software. Nobody understands whether rules of fair use will apply as courses move from a paper basis to global access over the web. How will revenues be shared between course providers, book and article publishers, clip art providers, and computer software developers? Will academic discounts for tools such as web browsers continue to be the rule when universities can package courses as electronic goods that can be bought and sold over the internet?

These questions are symptoms of the fundamental ambiguity at the very core of the transition from a manufacturing to an information based economy. Manufacturing age goods were made of atoms, so they are hard to copy and transport and thus straightforward to buy, sell and own. But information age goods are made of bits, so they are so easy to copy and transport that what it means to buy, sell and own them is very much open to dispute. My new book, *Superdistribution: Objects as Property on the Electronic Frontier* [Cox3], offers controversial proposals for how this issue is likely to be reconciled in the future.

Technology is merely an enabler. However what it enables is nothing less than human individuals, organizations and cultures, newly empowered to understand and misunderstand each other across time and space boundaries that have separated us since antiquity. The implications are too vast to be predicted, controlled or designed. Established institutions must either evolve to compete in this new global climate or be displaced by emergent new institutions who can.

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