Altering Time and Space through Network Technologies to Enhance Learning

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Abstract

This paper maintains that networking technologies offer a better learning environment for students while providing opportunities for reducing the cost of the learning process. A key outcome of advances in networking, the Internet, telecommunications, and client/server computing, is that they are serving to alter the limitations of time and place. The authors discuss their experiences from the perspective of teaching in economics and the arts. They have created learning strategies that make use of these technologies for communication and access according to a matrix showing the interaction of time and place. These include private news groups for each class; e-mail collaboration between students and between students and instructors; electronic submission and critique of work; electronic posting of grades, handouts, notices, schedules, etc.; electronic exhibit areas for multimedia and World Wide Web class projects; Internet-wide critique of work; Internet-based research projects; and the use of localized Internet servers dedicated to instruction.
A paradigm shift is taking place in higher education. According to Barr and Tagg (1995), the paradigm that has governed our universities is one that defined a university as “an institution that exists to provide instruction. Subtly but profoundly we are shifting to a new paradigm where a university becomes an institution that exists to produce learning.” (p. 13) We are beginning to recognize “that our dominant paradigm mistakes a means for an end. It takes the means or method—called “instruction” or “teaching”—and makes it the [university's] end or purpose.... We now see that our mission is not instruction but rather that of producing learning with every student by whatever means work best.” (p. 13)

Our paper addresses the following questions: will computing and networking technologies offer a better learning environment for students? Will these technologies improve our ability to help students produce learning while reducing the cost of instructional? We believe that the answers to these questions is a resounding “yes,” if computing and networking technologies are used to create learning strategies that involve students as active partners in their own learning.

In the search for active learning strategies, we are guided by two principles stated by Cobb (1993, p. 20):

- The student and teacher share responsibility for the quality of a process—the process of the student's learning (only indirectly and secondarily the quality of the teacher's teaching.)
- The core motivation, for both student and teacher, should be the satisfaction that derives from improving the quality of the student's learning.

Our goal as teachers in using computing and networking technologies is, to use a metaphor, to be a “guide on the side” instead of a “sage on the stage.” To return to Barr and Tagg’s (1995, p. 24) terminology, our goal is to move from an “instruction paradigm,” in which a faculty member’s role is “actor” and knowledge is transferred from faculty to students, to a “learning paradigm,” in which a faculty member’s role is “inter-actor—a coach interacting with a team” and students discover knowledge for themselves. We illustrate these contrasting paradigms in Figure 1.

Enhancing the Learning Process through Networking Technologies

In order to understand how technologies can support and enhance the quality of student learning and increase active participation by students, we share, in this paper, our experiences with implementing active learning strategies that use computing and networking. Chizmar teaches
undergraduate statistics and econometrics courses in a networked computer classroom where each student works on a computer workstation connected to the campus network and the Internet. Williams teaches two seminars on developing and designing computer applications in the arts. The first course focuses on designing multimedia applications with PowerPoint, Authorware, and HyperCard; the second course focuses on designing electronic arts exhibits on the Internet using a Web server, HTML coding, and a variety of graphics and music creative software tools. These courses take place in a traditional conference room with a computer teaching station, an overhead display, and a connection to the campus network and the Internet. Williams’s students also use a portable computer-lab-on-wheels on occasion in the classroom—a number of laptop computers are available on a cart, with wireless infrared networking—and they have access to a networked computer lab for work outside of class.

Networking and Internet connectivity is critical to our teaching strategies. We use a combination of AppleTalk for local networking and file sharing and TCP/IP connectivity to the Internet through MacTCP over Ethernet or Token Ring to the campus backbone (ISUNet). Chizmar’s web server is WebStar running on a Mac PowerPC in the economics department computer lab. Williams’s web server was originally a Mac server, but is now an SGI Indy running a Netscape server from the College of Fine Arts.

The network and server facilities that we have in place, provide for our students, to use Larry Smarr’s phrase, a “window into knowledge space” (1992). Smarr asserts that we are experiencing today the fruits of a major transition from a world of one person, one computer to a world of the “meta-computer,” a computer of computers. In this new world, a personal computer becomes a “window into knowledge space” and a gateway to virtual resources. But meta-computing does more than provide a looking glass through which to see the world. We believe that meta-computing also creates a looking glass that reflects back to the learner an image of him or herself working with other learners. Meta-computing enables learning by providing diverse modes of communication and access to a creative, virtual collaborative space for students.

Here is just a sample of some of the learning activities possible in our networked, meta-computing environment at Illinois State University:

- Private news groups for each class
- E-mail collaboration: student-to-student, student-to-instructor, and instructor-to-student
- Electronic submission and critique of work
- Electronic posting of grades, class handouts, notices, schedules, etc.
- Electronic exhibit areas for class projects
- Internet-wide critique of work
- Internet-based research projects.

In the remainder of this paper, we present examples of how we implement these activities in our classes. We find it useful to view these activities in terms of a time-and-place matrix, a concept we borrowed from writings on groupware strategies (Johansen 1992) and adapted to our work. A key outcome of the advances in computer networking and the Internet is that they are serving to alter the limitations of time and space. Each cell in the matrix (see Figure 2) demonstrates this by representing unique combinations of time and place events in fully networked learning environments. We start with same-time/same-place (representing the traditional classroom) and progress clockwise through different-time/different-place. You will see that, while we employ strategies that cover all the cells, they differ in Williams’s use of networking to enhance creative opportunities for his students and Chizmar’s use of networking to enhance collaborative activities.

**Same-Time/Same-Place Instruction:**

**Traditional Meeting Places**
Same-time, same-place describes the traditional classroom, rehearsal room, conference room, or computer lab. Our definition of “place” here includes both physical space (e.g., the classroom) as well as virtual class space (e.g., a dedicated server holding students' work and instructor's materials much as a work room or team room would be used).

Most efforts at incorporating technology into instruction have been focused on this cell of the matrix. This cell includes any meta-computing learning strategy that improves the ways in which students traditionally learn within the confines of meeting for 50 minutes, three times per week (same time), in the same classroom (same place). Such strategies include collaborative or groupware applications and experiences, in-class demonstrations, practical experiences especially with simulations, experiences with software applications, and in-class access to student and course on-line files. Chizmar makes use of simulation and in-class electronic collaboration and feedback within the same-time/same-place cell of the time-place matrix. Williams uses the computer for demonstration, hands-on practice, and critique of student work within this cell.

**Figure 2.** The time-place matrix showing instructional activities possible in a networked learning environment.

*Economics.* Chizmar uses statistical computing in a local area network setting to augment traditional face-to-face classroom instruction and to achieve the recommendations of the American Statistical Association and the Mathematical Association of America for the teaching of introductory statistics courses. These recommendations suggest that teachers should motivate students by showing them statistics at work in real applications, problems, cases, and projects; use real data and statistical computing; foster active learning; and downplay formal training in probability in favor of “exploring how useful ideas of statistical inference can be [learned] independently of technically correct probability.” *(Garfield and Ahlgren, 1988, p. 46)*

The last recommendation presents a conundrum. How can students gain an intuitive understanding of the concepts of probability by eschewing its formal study? Answer—through the use of computer simulation. Chizmar presents the central idea of a sampling distribution through a series of Monte Carlo simulation experiments. The Monte Carlo experiments give students an intuitive understanding of the Central Limit Theorem and can easily be answered using statistical computing. From their computer workstations in class, each student generates 20 random samples of the same size from the same population and for each sample calculates the mean and median. They then send Chizmar an e-mail message which contains their 20 means and medians. Again, within the class time, Chizmar combines each students response with the responses of the other students and
then e-mails these class distributions of the means and medians back to the students for further analysis.

Chizmar uses e-mail and a class LISTSERV to augment an active learning strategy called “think-pair-share.” This activity takes place collaboratively during class time. To help students clarify their thinking, Chizmar asks each student to write an e-mail message to the class LISTSERV, explaining, *in words their fellow students will understand*, a particularly difficult concept, a p-value for example. Students then read what other students have written and discuss differences or similarities with their teammates. The advantage of the LISTSERV in this context is that students know that their message is sent to the entire class. This version of “think-pair-share” is based on Meyers and Jones (1993) observation that “when we direct students to write to each other, they usually write with more clarity and precision.” (p.25) Klass (1995) has also observed when using LISTSERVs for political science writing activities, that when students write to a larger audience, in contradistinction to writing to the instructor, their writing in substantially better.

Chizmar also uses network computing to provide frequent feedback on the quality of student learning through a technique called the “One Minute Paper.” A typical One Minute Paper asks students to respond, in the final minute or two of class, to two questions: (1) What is the most important thing you learned today and (2) What is the muddiest point still remaining at the conclusion of today’s class?

The first question is intended to focus students on the big picture, i.e., what is being learned, and the second to provide specific statements of what students want to know more about, i.e., how well it is being learned. Chizmar has incorporated these question plus a set of Likert-scale questions developed by Shulman (1995) into a Netscape form (see Figure 3) which students complete at the conclusion of every class. The form creates a tab-delimited text file of the students responses which can be easily analyzed in Excel and Minitab. Furthermore, because the form also asks students to provide their e-mail addresses, Chizmar can respond immediately via e-mail to any student who seems particularly “muddy.”

![Class Assessment Survey](attachment://image1)

*Figure 3. A Netscape form for the “One Minute Paper”*
Before the next class, Chizmar creates a Pareto chart (a quality principles analysis tool) of the students’ feedback and fashions an e-mail message back to the students which contains the chart plus their verbatim responses to the One Minute Paper from the previous class. Students find the latter practice informative because it tells them, in unabridged language, that other students are muddy about the same points as they. Chizmar begins the subsequent class with a discussion of their responses, in essence, with feedback on student feedback. Chizmar observes that student responses became more thoughtful and useful as it becomes clear that he really does intend to use student feedback to manage and guide the course.

*Fine Arts.* Williams prefers a constructionist strategy of teaching with a strong emphasis on learning projects. A key strategy for the use of class time is viewing and critiquing work in progress. The guidelines for statistical study with emphasis on motivation, real-world problems and projects, and the downplay of formal training, apply here in the arts as well.

Williams uses the teaching workstation and its connection to the network to quickly access student work from the department server where class and private student folders permit electronic storing of assignments and work in progress. Students have an on-line folder for their work that only they and the instructor have access to. Having electronic access to all student projects makes it easy to quickly show and compare portions of students’ work and to isolate examples of problem areas in software and instructional development that need class attention. When hands-on is needed for learning new software development tools, as in Chizmar’s class, the portable lab-on-wheels can be rolled into the classroom.

**Same-Time/Different-Place Instruction:**
**Lowering the Walls of the Classroom**

Same-time/different-place computing lets us expand beyond the classroom. Here is where we “lower the walls” and open the “window into knowledge space.” Using the power of network connectivity and advances in cable and the telephony, collaboration takes on an expanded meaning. Any group of people can be brought together for a meeting at the same “time” without regard to “place.” We can hold text-based conferences (on-line chat groups), audio conferences (phone conferencing), and full-audio and video conferencing right from our desktop (desktop video presentations). Tutoring can be offered remotely. Mentors or experts can be brought into the classroom from anywhere in the world. Many programs are now offering their courses and degree programs on-line, letting students complete some, if not all, of their work remotely.
Fine Arts. Williams uses the teaching station’s connection to the Internet as a way to open the classroom to world-wide people resources. Active participation from the class on USENET newsgroups provides input and assistance from people throughout the Internet for information, problem solving, and even critique of student work. The newsgroups provide informal distance experts. Prearranged e-mail (using Eudora) and chat conferences are scheduled to synchronize with class time so that distance experts can share their talents, contribute to a class discussion, or help the students solve particularly difficulty problems or locate resources. Using Fetch, TurboGopher, or Netscape, a particularly rich resource of graphic images or music sound files can be queried and the files downloaded to the classroom for discussion and experimentation.

Economics. Chizmar uses the student station’s connection to the Internet similarly. Students, working in teams, use Netscape to access laboratory experiments designed to actively engage them in the study of statistics. One experiment, entitled “An Internet Journey” and adapted from an article written by Rossman (1994), asks students to answer a series of conjectures about life expectancy and density of people per television set in various countries. Working in teams of two, they link to an on-line journal, the *Journal of Statistics Education*, and retrieve a set of the data files across the Internet and import them into the statistical software, Minitab, for further analysis.

Future applications. There are other same-time/different-place activities which Williams and Chizmar intend to implement in the future: desktop video conferencing to bring distance experts and demonstrations into class in real time, prescheduled on-line tutoring for students with the instructor or a graduate assistant through controlled use of Internet chat groups (IRCs), and even the possibility of permitting students to attend the class remotely through desktop video conferencing.

**Different-Time/Same-Place Instruction:**
**Virtual Shared Space and Computer Labs**
This cell includes any learning activity which gives the instructor and students physical or virtual use of a dedicated workspace, any time they choose. Virtual team rooms, so to speak. We both provide local servers of information dedicated to class use, both for personal storage of work and for shared storage. This cell also would include dedicated physical workspaces. Our students have access to networked computer labs which they can use for “different-time” computing activities.

Chizmar and Williams both use a series of Web pages to organize on-line course content, where materials dedicated to their courses are stored. Students can find electronic versions of hand-outs and course syllabi. The well-worn plea for another copy of a lost handout is now followed by the rejoinder of “just download a new copy from the class server.” Grades are posted electronically after each assignment for those students who give the instructor permission to post grades. We make a GIF graphic image of a class spreadsheet and post it in the class server space where only the students in the class have access for downloading. Course materials for Williams’s class can be viewed at http://orathost.cfa.ilstu.edu/public/oratClasses/ORAT389.88Seminar/InternetModels/internetmodelshome.html and Chizmar’s class, at http://138.87.168.39/Jack_Chizmar/ECO131/Eco131home.html.

Fine Arts. Williams’s class makes extensive use of this cell and the virtual team room concept. Students construct off-line multimedia arts exhibits in the first semester course (Software Design in the Arts) and on-line multimedia exhibits in the second semester course (Internet Models for Artistic Expression). For these courses, students select a theme to develop for an exhibit which will be used throughout the semester. They then begin to design and accumulate a variety of digital imagery for their exhibits in private folders on the class server: digital graphics, digital video clips, MIDI music files, digital sound samples, text documents, and so on. Learning how to prepare such imagery, suitable to the multimedia platform they are working with (e.g., slide-, icon-, card-, or document-based tools), and of high aesthetic design quality, is a key goal of the course. The students then combine these images with Powerpoint, Word, Authorware, and HyperCard for the first semester course; HTML and Web page design for the second semester course. Examples of the work from the Internet Models course can be viewed through Netscape at http://orathost.cfa.ilstu.edu/public/oratClasses/ORAT389.88Seminar/InternetModels/exhibits95.html.

Williams provides each student with a private folder where only that student and the instructor can gain access to the materials. Special “drop folders” are created for submitting work electronically; files can be “dropped” in but only the instructor can take them out. Williams also creates on-line folders for each class project where students can share the results of their work with the class, and for the Internet Models course, with the Internet community at large. In fact, Williams requires his students to announce their completed projects on the Internet newsgroups and invite the public to electronically critique and react to their work. A local USENET newsgroup is created just for the class; this serves as an electronic bulletin board for the students and the instructor. Posts for help, advice, announcements, helpful tips, and coordinating student teamwork all circulate through the class news group over the semester. Williams feels that a LISTSERV would provide a more controlled environment for a collective newsgroup over the Internet. LISTSERVs are a good way to implement on-line critiques of work where several on-campus classes participate, or better still, where the same class at several different campuses share work with one another.
Economics. Chizmar has begun to experiment with out-of-class team projects. While exams and projects assess student understanding equally well, projects (especially team projects) more than exams are themselves instruments of learning. Because students teach each other, team projects promote student learning and empower students to own their own learning. The benefits of team projects can be substantially enhanced with the use of networking technologies which help to ameliorate a major complaint of student team members—that it is difficult to schedule a common time and place when everyone can meet to work on the project. Instead, telecommunication and networking technologies expand place and time by permitting students to collaborate in the same place, but at different times.

**Different-Time/Different-Place:**
**Access to the World of On-line Information**

The different-time/different place cell represents true “anywhere-anytime” computing. The freedom to participate at “different times” and “different places” lets the instructor and the students plan and control their participation and use of network resources to suit their own schedules and preferences. Through the World Wide Web and Gopher, data, software, and a wide array of graphic images, sound and music files, and digital movies can be transported to the classroom for use and demonstration. There are millions of servers with full-text documents, abstracts, on-line library catalogs, MIDI music files, digital sound samples, graphic images and digital video clips, software, and statistical data. The list is endless. Any location on the Internet containing these resources can be accessed at anytime.

Electronic mail, of course, is the most widely used different-time/different-place technology. With extensive use of e-mail for both students and faculty at Illinois State University, we have found that it has a great “social-leveling” or “equalizing” effect. When you interact with people through text only, people anywhere in the world, some of whom you have never met, the exchange is free from biases that are caused by visual appearances. We have found that students are much more likely to seek help from us via e-mail, then make an appointment to see us in our offices. We have also found that students are more likely to seek help from each other through e-mail, or from anyone in the
world for that matter. One student from Williams’s class convinced Guy Kawasaki to help him with his assignment simply because Mr. Kawasaki was impressed and intrigued by the way the student presented the problem to him (and found his e-mail address besides); another student managed to get help with multimedia copyright law by convincing a Harvard law student, through e-mail, to find the copyright information in the Harvard library.

Other examples of using networks for different time/place collaboration include electronic newsletters and journals, and electronic forums or LISTSERVs and USENET news servers.

_Economics_. We have already discussed Chizmar’s electronic adaptation the One Minute Paper. Chizmar also uses computing to augment another CQI (Continuous Quality Improvement) teaching strategy, the Quality Circle. A circle of six to twelve student volunteers meets weekly with Chizmar to provide advice and feedback on course management issues. Through the Quality Circle, students experience the direct application of simple statistical tools and procedures to a problem they know intimately—achieving learning of highest quality. Chizmar uses e-mail to facilitate the work of the Quality Circle—devising a fishbone diagram, constructing a class survey, composing recommendation to improve the course—and a LISTSERV to involve the remaining members of the class in the work of the Quality Circle any time, any place.

_Fine Arts_. This cell in the time-place matrix is another important one for Williams’s classes since students must conduct an extensive amount of research in developing their theme and thematic materials for the multimedia projects. One of the first projects in the Internet Models course is an Internet Treasure Hunt. The dual goals of the project are to acquaint the students with the basic Internet client tools for news, gopher, ftp, and web and to get them started with researching their topic area. The treasure hunt asks them to locate sites for graphic images, sound files, content information on their topic, information on copyright related to multimedia and the Internet, experts that can help them with their project, and grant and funding resources should they hypothetically need to seek financial support for the project.

![Figure 6: An example of a e-mail critique of student work.](image-url)
Williams also uses both on-line newsgroups and e-mail extensively in his class. Students are encouraged to use e-mail to communicate and collaborate with each other, and with the instructor. Through a combination of e-mail and newsgroups, students begin to think in terms of the learning process and the course of study being a 24-hour-a-day, seven-days-a-week experience, rather than a 50-minute-a-day, three-days-a-week experience; students, the instructor, and peers and experts worldwide, are always within reach.

Student work is submitted electronically through the class drop folders, and all work is critiqued with feedback being returned electronically to the student through e-mail. Figure 6 shows a sample e-mail critique. A standard template is used for each project that emphasizes the key objectives and criteria for the project. With on-line course materials, electronic submission of work, and e-mail critiques, no hardcopy or paper work exchanges hands during either of the fine arts courses (except for the class registration list and grade submission which still use op-scan forms!).

Reducing the Cost of Instruction

So far, we have addressed the question of whether using networked technologies can improve the quality of student learning and increase active participation by students. Obviously, our answer is a resounding “yes.” In the conclusion of this paper we would like to address the question of whether we can show a reduced cost of learning per student as the result of the innovations we have discussed.

Notice that we state the question in terms of the cost of learning per student rather than in terms of the cost of instruction per student. In this distinction, we agree with Barr and Tagg (1995) when they say, “Under the Learning Paradigm, producing more with less becomes possible because the more that is being produced is learning and not hours of instruction. Productivity, in this sense, cannot even be measured in the Instruction Paradigm [university]. All that exists is a measure of exposure to instruction.” (p. 23)

This distinction is not the usual ploy of defining away the problem, but rather of defining the problem properly in the first place. If we take learning as the proper metric, then we have no choice but to adopt learning strategies that produce active, involved learners. The lecture-discussion, the primary means of producing instruction in American universities, does produce a lower cost of instruction than active learning strategies. But we have increasing evidence that the lecture-discussion is ineffective at producing learning. As stated by Guskin (1994), “the primary learning environment for undergraduate students, the fairly passive lecture-discussion format where faculty talk and most students listen, is contrary to almost every principle of optimal settings for student learning.” (p. 6)

We also need to consider that increases in learning are difficult to demonstrate empirically because of what economists call “satisficing” behavior on the part of students. When given the opportunity through an active learning strategy, say, to learn more or to learn the same amount as previously more cheaply, students may rationally choose the latter because they too face competing demands—other classes, jobs, leisure—for their time. It strikes us, however, that insisting that there must be empirical evidence that active learning strategies coax out more learning than the lecture-discussion format is a little like insisting that before doctors could prescribe penicillin there must have been controlled experiments that demonstrated penicillin’s effectiveness. Doctors who prescribed penicillin did not need a study to see that their patients got better. Teachers who use active learning strategies do not need a study to see that their students learn more.

As a consequence, asking whether active learning strategies produces instruction at lower cost than the lecture-discussion, asks the wrong question. Rather we should be asking whether the learning produced by whatever strategy can be produced more efficiently. Here is where technology enters the picture.

As we have shown, networked computing, and, in particular, meta-computing, can be used to adapt already proven active learning strategies and produce the same or increased learning more cheaply. In terms of what? Primarily in terms of faculty time.

As faculty ponder whether to adopt more active learning strategies, they rationally compare costs and benefits. From a faculty member’s perspective, the cost of the technological backbone is a sunk
The sunk nature of the backbone is illustrated in a recent Doonesbury cartoon (November 28, 1995). Mike Doonesbury engages a colleague in the following dialogue:

Mike: Hank, what's a Web site?
Hank: It's an Internet presence.
Mike: What's on it?
Hank: It doesn't matter. Build it and they will come.
Mike: Why do we need one?
Hank: Because the technology exists. Also, everyone else has one.
Mike: What's my motivation?
Hank: Fear. Greed. Take your pick.

Universities have built it, but will faculty come? The primary cost that faculty members face as they ponder change is the cost of their own time. As it becomes clearer to faculty that they must give up the instruction paradigm in favor of the learning paradigm, faculty members will seek out ways to produce acceptable levels of learning with smaller and smaller investments of their own time. In this paper, we have discussed ways in which technology can be used to produce learning a lower cost in terms of faculty time.

The real question is what forces will cause faculty to change from an instruction to a learning paradigm, from the sage-on-the-stage to the guide-on-the-side. It is clear that this change is very costly in terms of faculty time, and that incentives must be created to induce this change. Perhaps Doonesbury is correct and the answer is “fear and greed.” We rather hope that the answer lies in a deeply felt understanding that the raison d’être of a university is not to produce instruction but rather to produce learning and that the traditional teaching strategies are ineffective. Again, in the words of Barr and Tagg, a university’s purpose is “not to transfer knowledge but to create environments and experiences that bring students to discover and construct knowledge for themselves, to make students members of the communities of learners that make discoveries and solve problems.” (p. 15)

Author Notes

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Footnotes

1These figures were digitally created by D.B. Williams from an original graphic of a sage-on-the-stage-like image by an unknown artist. We have not been able to identify the source of this image.
2Cross and Angelo (1988) and Light (1990) discuss the One Minute Paper.
3The Netscape form is only the latest incarnation of the One Minute Paper. Chizmar migrated from asking students to respond to the One Minute Paper first using paper and pencil and then using e-mail. The primary advantage of using the form is that it substantially reduces the analysis time—from over one hour to less than 15 minutes.

References


Smarr, L. (1992) Taken from an interview on NOVA PBS series on supercomputing and networking.