Technology and Teaching: Learning in a High-Tech Environment

Daniel A. Talley*

Dakota State University
Madison, SD 57042

E-Mail: Daniel.Talley@dsu.edu
Phone 605-256-3279

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*Daniel A. Talley is assistant professor of economics at Dakota State University, Madison, South Dakota, 57042.

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Abstract

This paper surveys the use of different technologies in teaching principles courses. In courses taught in 1998 and 1999, students in Principles of Microeconomics were exposed to a variety of technologies including: Internet-based course material (syllabus, grade reports, homework assignments, sample problems and solutions), remote simultaneous two-way televised lectures, streaming video lectures available over the Internet, examinations taken over the Internet, and electronic textbooks.

This study describes these technologies and discusses how they were implemented and used in an economics classroom environment, assesses both the benefits that they can provide as well as issues that limited their effectiveness in learning, and compares outcomes in those courses to courses in which the students had the same instructor but were not given access to certain technologies. By examining survey data and comparing course grade outcomes, several hypotheses regarding the effectiveness of teaching using technology are tested.

The central conclusion is that while specific technologies are highly favored by the students, as indicated in evaluations, there is a lack of strong statistical evidence of improvement in learning outcomes as a result of the implementation of most of these technologies. Recommendations to improve the effectiveness of the technologies for advancing learning conclude the study.

I. Introduction

This paper examines a wide range of techniques and technologies that are available to enhance the teaching of economics at the introductory level. While the focus of the paper is to provide some guidance and suggestions for instructors interested in enhancing their courses with these technologies, the author is also interested in evaluating the relative benefits to the students as well as the costs to the instructor of their implementation. To this end, comparisons of courses taught by the author over a period from 1997 to 1999 are constructed with the goal of evaluating student learning, as measured by grade and exam outcomes and end-of-semester student evaluations, called Student Opinion Surveys (SOS) at Dakota State University.

It has been repeatedly asserted that the use of technology in the teaching of economics is an area of significant potential benefit. Becker (2000, p. 113) identifies pedagogy involving the use of the Internet as one of two types that "seem especially well-suited to the teaching of economics." Becker then comments on the Internet's potential to involve distance learners interactively in the educational process. Indeed, the Internet's potential benefits are not limited to distance education--face-to-face learners in the classroom/lecture environment can also benefit substantially from use of the Internet. The ability to access up-to-date data, news, and analysis on current events (oil price shocks, Fed interest rate hikes, etc.) and recurring themes of economic interest, such as deficit reduction, saving Social Security, the declining U.S. savings rate, and the ever-expanding trade deficit to name but a few, cannot help but spark the interest of the students and empower them to explore these issues outside the classroom at minimal effort. This provides an effective pedagogical "boost" to the effectiveness of the lecture, the dominant teaching method in economics (Becker and Watts, 1996,1998).

The use of the Web[1] to promote interest in economics is well recognized in the literature. Simkins (1999) provides a concise characterization of the primary benefits of the Web as a rich source of economic news, data and information, that can be presented in a variety of formats (video news clips, audio speeches, and primary source written material) and as a method of broadening the education experience beyond traditional

[1] While acknowledging that the World Wide Web is a subset of the Internet, the terms "Internet" and "Web" are used interchangeably in this paper.

teaching methods through the use of student-authored Web-based magazines, online stock-market trading games, macro- and microeconomic simulations (see for example, Fair (1999) and Daniel (1999) respectively), and Web-based tutorials. In addition, course web sites and e-mail can provide effective course information dissemination including information on grades and course standing, homework assignments and due dates, discussion forums among students for course topics, and opportunities for question and answer sessions with the faculty member outside of office and class meeting hours. All of these uses of the web have been described as exerting a positive influence on students' attitudes toward economics to some degree in the literature. (See Manning (1996), Agarwal and Day (1998) and Parks (1999) for recent examples of the use of these technologies, among others.)

The effect of Web technologies on learning is less conclusive. As noted by Simkins (1999), Sosin (1997) has found that most of the available evidence is anecdotal and there are few empirical studies that focus on the teaching of economics at the college level. Moreover, the most comprehensive study to date (Russell (1997))--in a study that summarizes the results of nearly 250 research reports, studies and papers--finds that the vast majority fail to refute the hypothesis that there is "no significant difference" between the learning achievement of traditional classroom education and those students who are taught using technology.[2]

A notable exception is Agarwal and Day's (1998) study of the impact of web-enhanced teaching on their students. Using a classic control-experiment methodology, this paper provides an empirical analysis of the effect of the technology environment on student learning. Their methodology is used in this paper to analyze the central claim made here and elsewhere: That the introduction of technology will not on its own improve learning.

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[2] Some see this as a tacit endorsement of technology by arguing that a "Hippocratic Oath" approach to education is acceptable; as long as we "do no harm," the use of technology in teaching can be supported. Economists do not find this line of reasoning convincing on two fundamental grounds: First, the additional costs involved in any investment in the use of technology must be justified by an expected future stream of benefits, even in education. Second, as any good econometrics student can tell you, failing to reject the null hypothesis of "no significant difference" does not imply we can accept it as true. Our test may merely not have enough power to reject the null in favor of the other tail, i.e. that the students are slightly worse off. It is especially important to remember that statistical tests are biased in *favor* of the null hypothesis.

Agarwal and Day (1998) find empirical support for two conclusions: They reject both the hypothesis that the Internet has no impact on student learning and retention in favor of a positive influence and that the Internet has no impact on student perception of instructor effectiveness as measured by end-of-semester student evaluations. Moreover, they find empirically mixed results but generally positive effects of the Internet on student attitudes toward economics: significant among graduate students, no significant difference for undergraduates. This study adopts their methodology to highlight some of the difficulties in achieving significant improvement in learning.

Four microeconomic principles courses taught in the fall of 1998 and summer of 1999, where various technologies were added incrementally to each class, are tested against a baseline course taught in the fall of 1997 that was taught completely by traditional classroom methods. Three of the courses were taught in the same semester, with two of the classes receiving web-enhancements exclusively and the third receiving a CD-ROM-based textbook that replaced the required textbook used in the other courses. The web-enhancements took the form of an extensive course web site that provided them with access to a copy of the syllabus, a grade report (keyed on a unique, randomly-generated four-digit number issued to each student at the beginning of the semester), all homework and Internet course assignments, chapter-by-chapter lecture notes created by the instructor in Microsoft Word format, sample midterm and final exams (also Word format) and their answer keys, and to a links page to other sites with interesting economic content. The summer course also made use of the full-featured course web site and the same CD-ROM textbook, but included two new innovations. The course was split 50/50 between students taught in the same classroom and students taking the course 50 miles away and watching it on a two-way interactive television system. In addition, these televised lectures were recorded on videotape each evening and then digitized and made available over the Internet as streaming video files. Thus, the entire course, including in-class discussions with the students both face-to-face and remote, was available over the Internet.[3] Moreover, online testing was employed for the midterm and final examinations, allowing the students to take their exams over the Internet.

[3] It had been intended to also offer the course to true Distance Education students in an asynchronous mode--they could watch the lectures as time permitted. But due to a failure to advertise the course in advance, no distance education students signed up for the course and the pure distance aspect was never

This study examines the effectiveness of the various technologies used in these four courses. Section II consists of an overview of the high-technology environment at Dakota State University. This is followed by a discussion of the courses and the technologies employed in each, along with some discussion of their beneficial and detrimental attributes, in Section III. Section IV presents an empirical analysis of student learning, as measured by the students' course grade and performance on the final exam, using the methodology of Agarwal and Day (1998). The paper concludes with a summary of the results and suggestions for improving learning through the use of technology.

II. A High-Tech Environment

Before a more thorough presentation of the technologies is made, it is necessary to provide some background about the environment in which these technologies were employed. Dakota State University is a small public university, one of six institutions of higher education in the South Dakota regental system, with a current enrollment of approximately 2000 students. In 1986, the institution underwent a mission change that transformed it from an institution focusing on teacher education to an academic environment with an emphasis on the integration of technology throughout the curriculum. It's new legislated mission[4] was to focus on the implementation of computer technology programs and other related undergraduate and graduate programs. In particular, it was authorized to offer programs in business and information systems, focused on the application of computer technology to business, and was also mandated to integrate technology into all aspects of the curriculum.

Thus, the environment at Dakota State is heavily oriented toward the use of technology. All students have e-mail accounts, all dorm rooms are wired with multiple access ports for multiple residents, so each student can connect their computer to the university network. Students are not required to own a computer, as there are ample computer facilities available. There are computer labs in each of the residence halls, as well as in every academic building and the library. The student union also has a lab, but

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tried. Since I occasionally broadcast from the remote site back to the campus site (as recording equipment exists at all sites), there was some face-to-face contact with all the students in the course.

[4] See South Dakota House Bill 1357, as enacted February 29, 1984, by the legislature of the State of South Dakota for the specifics of the mission change.

the computers that get the most use are the ones on carts that can roll from table to table in the common dining area. The student FTE (full-time equivalent) to computer ratio at the university is 4.4 to 1, with approximately one-quarter to one-third of all computers on campus replaced each year. In addition, all students are required to take a three-semester-hour introductory course in the use of computers that includes training in the use of e-mail, the Internet, and the Microsoft Office suite of software (Word, Excel, Access, PowerPoint, and FrontPage), thus gaining some comfort with the writing, analysis, database, presentation, and web design tools that they will be exposed to in their courses at the university. Moreover, all students are required to take a second three-semester-hour computer principles course that teaches them a programming language. Both courses are usually completed in the freshman year and generally prior to enrolling in a principles of economics course (both micro- and macroeconomics partially satisfy social science general education requirements).

The faculty throughout all four colleges (Business & Information Systems, Education, Liberal Arts, and Natural Sciences) are highly computer literate and are encouraged to make innovative use of technology in their courses. Dakota State University has been nationally recognized for its integration of computer technology into all aspects of its curriculum; the university has twice been ranked in the top 15 (#12 in 1998, #10 in 1999) of the 100 Most-Wired universities in the nation by Yahoo! Internet Life magazine, based upon annual surveys that examine both the *level* and the *use* of computer technology by a university. Distance education courses have been offered since 1996 at DSU and this author will offer the institution's first Internet-based distance education course in microeconomic principles in the summer of 2000.

It should be made plain at this point that, although the university could be characterized as a high-technology environment, the students that come to Dakota State are not necessarily the most highly computer literate in the nation. Entrance examinations clearly illustrate that the representative DSU freshman student is not much different in background from freshmen at the other state universities in South Dakota.[5] While the integration of technology into the K-12 environment is ongoing, most DSU

[5] Information about the six public universities, including data on entering freshman class characteristics, can be found at the South Dakota Board of Regents web site: http//www.ris.sdbor.edu/home.htm.

students are graduates from small, rural high schools in South & North Dakota, Minnesota, Iowa, and Nebraska and may have had little experience with computer technology.

However, in my own experience and from discussions with colleagues, the main difference between students that attend DSU and those who do not is that DSU students are more willing to be exposed to new uses of technology. An expectation of, or at least a tolerance for, experimentation with new technology in their courses is common among the students. And since many have not attended another college, they soon adapt to the technological environment. Indeed, they sometimes forget that not everyone routinely checks their e-mail five times a day!

This discussion is therefore intended to serve as a warning to those reviewing the materials described below and included in the appendices to this paper--they are designed for students who do not demand to be coddled in their exposure to technology. Students are expected to know how to find material on the web, to use computers to present their work, and to communicate routinely using e-mail. An accurate description of the materials presented here would be that they are functional in their objective--easy to use but not overly sophisticated in their construction. It is quite possible that they may not be as user-friendly as they might need to be for effective use in a less technologically-oriented institution, but could easily be adapted to provide more "help" and "directions" features.

A major advantage for the prospective user of the technologies described below is that one need not possess a computer programming background in HTML, Java, or anything else to use them routinely. For example, the online course grade book is created using two commercially available software packages, Microsoft's Excel and FrontPage. It must therefore be updated manually, but the procedure for saving the grades spreadsheet in HTML format and then inserting the saved file directly onto the web page is simple enough that an undergraduate work-study student can do it (after fellow student's names have been appropriately removed from the spreadsheet to protect privacy). However, the purpose of this paper is to demonstrate some perhaps less well-known technologies that are available to the instructor of economics, and therefore will not dwell further here on how to implement them.

III. Technologies for Teaching

This section will explain the different tools available to the instructor of economics. It progresses from providing more detail regarding the materials available on the course web site common to all four courses, to a discussion of the electronic textbook used in two of the courses, next to a description of the two-way interactive television system, and concludes with a discussion of the use of Real Player video files to distribute recordings of the lecture over the Internet.

In the summer of 1997, a Distance Education Summer Grant was awarded to this author by the university for the purpose of creating a web-enhanced principles of microeconomics course in 1998. The grant specified work in three areas: The creation of a complete set of chapter-by-chapter lecture notes that could be distributed over the Internet and taken by the students to each lecture, creation of homework assignments using materials accessed by the Internet, and creation of a page of links to interesting and/or entertaining web sites that were relevant to the economic content of the course. In the course of performing this work the microeconomics course web site expanded to include important course information that the students can access at any time.[6]

As mentioned above, the web site now routinely contains syllabus, lecture notes, lecture- and Internet-based homework assignments, current grades spreadsheet, sample tests and answer keys, and a links page to a few sites of interest. Depending on the particulars of the course, it may also contain a link on information for installing Real Player software to play video files on your web browser and a link to download the actual lecture recordings (which can be saved on the student's computer or viewed immediately--streaming video technology allows the student to watch one part while downloading the rest of the recording). See Appendix A for screen captures of the course web site for Spring 2000.

This technology takes advantage of the significant opportunities offered by the Internet for information dissemination when used to supplement a traditional classroom-based course. This forms an important supplement to the classroom lecture format that is

[6] The course web site for ECON 201 Principles of Microeconomics Spring 2000 can be found at the following address: http://courses.dsu.edu/econ201/201Index.html. Note: I am not recording my lectures and am using a paper textbook this semester. Real video files of lectures will be available for unrestricted

the dominant form of content delivery in these classes--in many ways, these courses fit the 'stereotypical' economics course described by Becker and Watts (1996), taught by a Caucasian male with a Ph.D. using primarily the 'chalk-and-talk' approach. However, the web has significantly improved the delivery of those lectures, both from my perspective and for the students, as measured by the proportion of positive to critical comments on evaluations for the last few years.

Each of the other facets of a course web site also improve student learning. Students must learn to allocate their time for classes, study, socializing, etc. and up-to-the-minute, accurate sources of information on their status in a course facilitates that activity. In addition, the lecture notes obtained over the Internet are only partially completed--space is left for important definitions, explanations, examples, and graphs that are supposed to completed by attending the lecture. In addition, some concepts are discussed "off the top of my head"--not explicitly a part of the lecture notes--and are fair game on the examinations since the test covers the material discussed in the lecture, not only the lecture notes. This provides an added inducement to come to class (and indeed casual empiricism reveals attendance has improved in recent semesters). See Appendix B for an example of the chapter lecture notes.[7]

It might be argued that the lecture notes and the online syllabus are not properly Internet technologies since they could just as easily be printed and distributed to the students in class. This criticism would be correct if they did not have hyperlink web addresses imbedded in them--and if I never made mistakes. The ability of the student to explore the classroom concepts at the click of a mouse is undoubtedly a powerful facilitator of interest in the class. And the ability to modify, correct, and edit materials that have already been distributed merely by informing the class of the change shifts responsibility for staying up-to-date in the classroom materials from the professor to the student. The excuse "But I wasn't there when you handed it out..." is eliminated when the student has the responsibility to obtain the material from the web site. (Indignation

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access and viewing during June 12 - July 7, 2000 when my summer course is underway. An archive is under consideration.

[7] The lecture notes in Appendix B are provided for classroom discussion of the material in Chapter 6 "The Costs of Production" of Bradley R. Schiller's *The Microeconomy Today*, 8th edition.

subsides fairly rapidly when the reply is: "It was on the web site the day before you missed class and you could have downloaded it at any time...".)

Moreover, the Internet has allowed for the inclusion of a wider range of assessment devices, including the assignment of a research paper that requires the use of the Internet. This has moved the course one step closer to a more active learning approach. According to Chizmar and Walbert (1999) an important element of Web use for pedagogy is that it assists students to discover important concepts on their own. The Internet-based assignments force students to apply their critical thinking skills; they must identify and assess different (and sometimes conflicting) sources of information that they have discovered on the Internet that are relevant to the assignment at hand. Involving the students directly in the evaluation of source material enhances their learning (in a way not easily assessed, as discussed later in Section V) and gives them experience in developing an important 'life-long learning' skill, conducting self-directed research, that will be of use long after the course has ended. See Appendix C for an example of an Internet-based research assignment.

As mentioned above, the course also contains weekly homework assignments (except during weeks in which there is an exam), a grades report page where I publish my course grades spreadsheet to the web sans names, sample midterm and final exams with their keys on a separate web page to be used as practice exams and study guides, and a links page for students to pursue at their leisure. All exams consist of four-part multiple-choice questions (30 on a midterm, 50 on the final) and the students are allowed to keep the exams. The answers to each exam are published on the web site immediately after the examination ends, usually within half-an-hour (if I do not teach another class after the exam), and the grades are posted as soon as they are entered into my course grades spreadsheet. Web publishing using Microsoft FrontPage can occur from either my office or my home through a modem connection.

Students greatly appreciate the immediate satisfaction of determining their score since they can record their answers on both the answer sheet they give to me and on the test they keep and determine how well they did soon after the exam is over. This is true to a lesser extent on the other homework assignments as well. And the students will routinely contact me immediately, often by e-mail, if there is an error in the key, allowing

the correction to be made before starting to grade their exams in earnest. In conjunction with e-mail links to me and links to various other college and university home pages from every web page, these features have been available on the course web site for the economics principles courses each semester since Spring 1998.

A more recent innovation spearheaded by a few publishing companies (or their software publishing subsidiaries in this case) in recent years has been the introduction of computer courseware on CD-ROM. In 1998, I was contacted by Archipelago Productions to review a product called Archipelago Microeconomics Online Course. It consists of a set of CD-ROMs to install the necessary software to connect to their web site and set up a course for principles of microeconomics, complete with a roster, grade book, and online quizzes and examinations. However, the most intriguing aspect was the CD-ROM textbook that came with the courseware. The textbook uses Apple's QuickTime to show "lecture" movies over the textbook material. Each chapter is divided into modules with their own presentation, possibly including news clips, animation, video, web activities, supplemental exercises with answers, as well an editor that gives the instructor the ability to customize any and all of it. Since the chapters are downloaded to the hard drive (instead of being played off the CD-ROM), the action is much smoother and the instructor can modify it to their liking.

The software was pilot-tested in the fall of 1998 (in Section 01), and the software was offered to the students for free in lieu of the traditional paper textbook used in the other two sections. The students were not told until the first day of class that the software would be provided for them. In addition, the software was installed in several computer labs around campus. The students only had to have the first CD-ROM to use the software at any of the on-campus labs. This was particularly far-sighted, as it was later discovered that many of the students had significant difficulty following the directions for installing the software and simply used the labs to do all of their studying. In addition to the software, each student also receives a large binder that contains PowerPoint-style printouts of each screen presented by the software, with the idea that students could use this as a notebook. Since the students were already provided with the course lecture notes, this oversized binder was not frequently used.

At the end of the semester, the students completed a questionnaire sent by Archipelago and modified to include questions about the course web site. The questionnaire is included in Appendix D. To summarize, the students who were computer-savvy enjoyed the software and felt that it was best used to complement a traditional textbook in a traditional lecture style course (as opposed to replacing the textbook and/or lecture, or for use in a distance education course). The students who could not install the software, did not have a computer at home, or made use of it mostly in the labs were less enthusiastic about the experience.

Since the course had its own web site, the second page of the survey was generally ignored or confused with the course web site. The last page of the survey focused on the course web site at DSU (in its second semester of existence). The site was accessed "occasionally" to "very often" by the majority of the class. The "chapter lecture notes," homework assignment page," "course grades spreadsheet," and "examination answers page" were found most useful, with the emphasis most commonly on the lecture notes. The "syllabus" and/or the "selected econ sites" (the links page) were most frequently indicated as being used the least.

Among the most requested improvements to the web site include "additional assignment information and hints," "online midterm examinations," "self-assessment exams and quizzes," and a "frequently asked questions and answers page." These are areas that are likely to appear (or have already in the case of online examinations) in the future. Finally, the students did not seem to care in what format their assignments were distributed over the Internet--and remarkably none of them expressed a desire to return to handing out assignments in class, implicitly indicating a preference for the web delivery. All indicated the web site was very easy to use, but that result could have been influenced by the fact that the online textbook was not as easy to use.

The Archipelago textbook was again selected as the sole textbook for the principles of microeconomics course taught in the summer of 1999. This time however 1) the students had to purchase the online courseware, 2) some of the remote-site students did not have access to adequate computers at home or at the university, and the remote location would not let them install the software in their labs, and 3) some of the students were from other universities and therefore were not accustomed to being asked to use

technology to this degree, even though they had been informed the course would be offered by a DSU professor and would also make use of two-way television technology. The combination of these factors led to the first-ever withdrawal by one of the students from one of my economics course *because* of the required use of technology.

To summarize the advantages and disadvantages of the CD-ROM textbook (which was the limited manner in which the courseware was used in these two courses), it has the advantage of providing a more interactive, more engaging medium through its use of video and audio, while at the same time giving students considerable control and the ability to "replay" lesson material. However, the technological sophistication required to install the software, download the chapters from the web, and successfully navigate the interface proved to be too challenging for some students.

Moreover, some students frequently voiced the complaint that, while they could study wherever they wanted with a traditional textbook (dorm, lounge, cafeteria, car(!), etc.), they had to have access to a computer to study with the CD-ROM textbook. Even in a high-tech environment, computers are not as ubiquitous as tables and desks. I suspect these concerns would arise with other such software, such as Navarro's *The Power of Macroeconomics* and the online or web-based textbooks referred to in Sosin (1997, pg 7), among others.

As mentioned above, two-way interactive television technology was used in the Summer 1999 microeconomics principles course as well. This is not an Internet technology, as it requires the broadcasting and receiving sites to be connected by fiber-optic wires to achieve instantaneous communication between the sites. The state of South Dakota has a complete system of RDTN (Rural Development Television Network) sites and it is possible for multiple sites to be connected in a conference. The course only had one remote site, in Sioux Falls, SD, approximately 45 miles distant from the Madison campus. Of the twenty students at both sites, eight were taking the course from Sioux Falls. The course was structured over an eight week period, meeting twice a week for three hours a night. Essentially one week's worth of material was covered each evening. The instructor was not required to conduct each evening's lecture from more than one site, but in the interest of actually being able to *recognize* the students who were taking the course, and in the interest of improving their interaction, the instructor traveled to the

remote site the week prior to each examination. It appears that the face-to-face contact was appreciated, as judging by the end-of-semester evaluations (presented in Section IV below).

The primary advantages and disadvantages to the use of remote teaching are fairly common to anyone who relies solely on technology for the transmission of content material. Just as Parks (1999) recognized that he must always be prepared to do a 'chalk-and-talk' lecture in case his dependence upon the computer for the PowerPoint presentations proved unwise, using two-way interactive television means being even more dependent on the technology working perfectly for effective communication. Although not in this particular course, there have been problems with either audio capabilities, video capabilities or both with this system (including as recently as Fall 1999), and that means that both sites must wait until the connection is restored by technicians working on the server in the capital (Pierre, SD) over two hundred miles away.

However, if that single crippling disadvantage is avoided (or swiftly corrected) as in this summer course, then the technology can effectively accommodate a wide range of student needs. Moreover, the studio has the ability to record the sessions to videotape (as well as play them), and the view on the TV screen can switch from a camera view of the instructor, to a camera view of the audience, to a view from an "overhead" projector that can effectively serve as a "chalkboard," to the view on a computer monitor that is connected to the university network and, therefore, the Internet. (This is the only class in which the computer was occasionally used in the classroom to illustrate how to find material from a web site.) The cameras automatically switch from location to location based upon noise source. Thus, a student at the remote location can interrupt to ask a question at any time. Moreover, more sophisticated systems can allow the cameras to automatically track the movements of the speaker and would therefore be less constraining than the current system that requires the instructor to stay in the camera's field of vision.

The last technology makes use of the ability to videotape lectures afforded by the two-way interactive television system. The Office of Distance Education purchased software called Real Producer (from Real Networks, Inc.) and can use it to encode video

and put it onto a web site in streaming video form. (Streaming video allows a viewer on the web to watch the part of the video that has already arrived over the web while the rest of the file is still being transmitted. This avoids long delays created when downloading large video files.) The three-hour lectures were recorded each evening, broken up into approximately one-hour lengths (at natural breaks in the lecture), and encoded into three files that could be linked to from the course web site. The students were required to install Real Player video software (free from Real Networks and available from the Dakota State University web site) in order to play the lecture recordings. The video quality was intentionally designed to be low (the low frame rate is noticeable because the action appears jerky, even though the audio is very smooth) to keep the file size to a minimum and allow transmission of the files over older modems.

The potential to broadcast classroom lectures, complete with student discussion, questions and answers, could prove to change the nature of distance education. Instead of set-piece, choreographed video, the distance student has the opportunity to watch the professor in action in front of real students, discussing current events, e.g. an oil price shock that occurred last week, as a diagram of the event and its implications are depicted using (aggregate) supply and (aggregate) demand (for macroeconomics). The distance student can get a much better sense of the classroom interaction that is typically missing in distance courses. Of course, the distance student must still be provided with a means for asking his or her own questions, such as through e-mail, a discussion group, or a chat room. The fact that professors become used to relying on students for visual and audio cues as to the effectiveness of their lecturing, to alert them to a need to slow down and explain something more thoroughly or move on to the next subject because a point was especially well made, is another reason that the usefulness of taping live courses could lead to more effective learning, especially in a distance environment.

Even though this course had no distance students, the video was an extremely popular tool for reviewing key parts of the lecture when studying for exams. The students appreciated being able to advance, rewind and pause the lecture so that they could better clarify their understanding and record the key concepts they may have missed in their notes. The author is unaware of any other use of streaming video technology in an economics principles course to date.

IV. An Empirical Examination of the Impact on Learning

Agarwal and Day provide a concise summary of the primary drawbacks facing the potential adopter of technology in teaching an economics course: "Use of the Internet, however, implies significant learning costs for some students because they are being exposed to the technology for the first time. The beneficial results of the technology on learning and retention could be offset by the time costs of learning the new technology. Increases in student workload caused by Internet requirements and resistance to learning and using the technology could result in lower scores in instructors' evaluations and in student attitudes toward economics. The impact in each of the three areas could be positive or negative." (Agarwal and Day 1998, p. 100)

Therefore, it is important that the appropriate checks for benefits be taken to determine if the use of technology in teaching has reached the level in which the benefits are clearly significant, at least in a statistical sense. The purpose of this section is to test two of the three hypotheses advanced in Agarwal and Day (1998):

1. Internet implementation in economics courses has no impact on student learning and retention, as measured by course grades and performance on multiple choice examinations.
2. Internet implementation in economics courses has no impact on student evaluations of instructor effectiveness, as measured by end-of-period student opinion surveys.

These hypotheses are tested against two-tailed alternatives. The rationale for expecting to reject these hypotheses in favor of a positive results correspond to those described in Agarwal and Day (1998, p. 101).

To test the hypotheses, the four courses described above conducted in the fall of 1998 and summer of 1999 are compared against a 'control' group, a principles of microeconomics course taught in the fall of 1997.[8] Although the courses vary temporally (all courses were taught by the same instructor), the students were allowed to self-select into the different courses, and similar classroom instruction style, tests, and homework were used in both groups. The syllabi from all five courses are presented in Appendix E

[8] In Fall 1998, the author's teaching load was three ECON 201 Principles of Microeconomics (Sections 1-3) and one BUS 321 Business Statistics II (the second semester in the one-year statistics sequence, focusing on applied statistics and regression analysis). Section 1 is the section that used the Archipelago Online Courseware (the CD-ROM textbook).

and the actual final examinations from all of the courses except Summer 1999 (online) are in Appendix F. The examination questions are remarkably consistent.

Data were collected on student characteristics that were found to be significant in Agarwal and Day, specifically, gender and GPA.[9] The characteristics of the five groups are presented in Table 1 below.

Table 1

Demographic Characteristics of Control and Internet Groups

	Internet Groups				Control
	Mean	Mean	Mean	Mean	Mean
Variable	Summer 99	Fall 98, Sect. 1	Fall 98, Sect. 2	Fall 98, Sect. 3	Fall 97
Gender[a]	0.556	0.591	0.604	0.477*	0.585
GPA	2.882	2.956	2.830	2.600*	2.914

[a] Proportion of males.

* Significant at the 95% level of confidence.

The courses are listed in reverse order of technology usage, that is, from most to least, with the control group presented at the far right of the table. The only group that appears to have significant differences from the control group in both Gender and GPA is the Section 3 of Fall 1998. This may have implications in the results presented below. The students in the remaining three groups appear to be homogeneous in their characteristics when compared with the control group.

Differences in student learning and retention resulting from differing degrees of exposure to the various technologies were measured using the student's final course grade and the final examination. Although, the use of the Test of Understanding College Economics III (TUCE), developed by the National Council on Economic Education, would have been a superior instrument, the final examination of the course remains remarkably consistent from semester to semester (50 four-part multiple choice questions) and has the distinct advantage of only asking questions over areas that were emphasized in the classroom lecture. However, the study could clearly be improved by the use of a

[9] Agarwal and Day (1998) also collected information on mean age and race but those variables were found to be consistently insignificant at the 95% confidence level in the regression results they presented. They also examined the effect of level of education (graduate versus undergraduate), but Dakota State University did not offer its first graduate programs until the fall of 1999.

nationally normalized test that is more likely to avoid any potential bias in difficulty from semester to semester.

To examine the second hypothesis from Agarwal and Day (1998), the standard instructor evaluation form used at Dakota State University, the Student Opinion Survey (SOS) was used in an unmodified form. Several of the questions asked are quite similar in form and intent as those used in the survey administered in Agarwal and Day. In addition, the SOS has the advantage of asking students to evaluate this specific statement: "Computer exercises/projects helped me to better understand course content." The students are required to rate the instructor by evaluating 21 different statements on a five-point Likert-type scale (1 = Strongly Disagree, 2 = Disagree, 3 = Undecided, 4 = Agree, 5 = Strongly Agree). They are also allowed to write optional comments on the back of the survey answer sheet. Nine of the 21 different questions correspond quite closely to the questions chosen in Agarwal and Day (1998) that deal with student perceptions of instructor effectiveness.

Regression analysis was used to test the hypothesis that the Internet has no impact on student learning and retention of economic concepts and comparisons of the mean responses were used to test the hypothesis that the Internet has no impact on students evaluation of the instructor's effectiveness.

The following regression models were used to test student learning and retention as measured by one of the two dependent variables: scores (out of 50 possible) received on the final exam in each course and final grade in course.

$$\text{Final} = \alpha_1 + \alpha_2 I + \alpha_3 G + \alpha_4 GPA + \varepsilon \qquad (1)$$

$$\text{Grade} = \beta_1 + \beta_2 I + \beta_3 G + \beta_4 GPA + \nu \qquad (2)$$

where

Final = student score on final examination
Grade = final student grade in class (out of 100%)
I = Internet variable (0 = control group, 1 = Internet group)
G = gender variable (0 = female, 1 = male)
GPA = student GPA at last registration
α, β = the coefficients to be estimated
ε, ν = normally distributed error term for each equation

Each Internet group data is combined with the control group individually to form the data set for the two regression equations. This causes the sample sizes to vary based on the class sizes of the different Internet groups. The results of the regressions are given in Tables 2 and 3. Recall that Fall 1998, Sections 2 and 3 received web-enhancements to the traditional classroom lecture, while Fall 1998, Section 1 additionally used a CD-ROM textbook and Summer 1999 used all of those technologies, plus two-way television and Internet video of the lectures.

Table 2

Regression Analysis for Performance on Final

Independent variable	Final			
	Summer 99	Fall 98, Sect. 1	Fall 98, Sect. 2	Fall 98, Sect. 3
Constant	15.67	10.40	18.02	13.92
	(.0001)	(.0032)	(.0001)	(.0001)
Internet	3.63	0.1422	0.0039	1.76
	(0.0091)	(.9169)	(.9972)	(.1170)
Gender	1.75	2.09	0.7180	2.78
	(0.1449)	(.1120)	(.5404)	(.0140)
GPA	5.50	7.27	4.93	5.93
	(.0001)	(.0001)	(.0001)	(.0001)
Regression Statistics				
Observations	71	75	106	97
R^2	0.40	0.41	0.22	0.32
Adjusted R^2	0.37	0.38	0.20	0.29
SE	4.87	5.36	5.77	5.19
F	14.77	16.13	9.69	14.33

Note: Parentheses contain *p* values.

In Tables 2 and 3, students in the groups that had Internet and other (two-way television, online textbook) technologies do not, for the most part, appear to perform better than the control group that had no access to these technologies. This conclusion is reached in all cases, except for the Summer 1999 group with regard to their final exam. This group rejects the null hypothesis of no improvement in learning at the 99% confidence level.

However, this is only one of eight tests that support the results obtained by Agarwal and Day (1998). It is interesting to note that although gender also alternates between significance and insignificance (significant only three times at the 95% confidence level and largely only for Section 3), GPA is clearly an unambiguous predictor of performance on the final exam. Agarwal and Day also found that GPA was a strong determinant of performance, although gender was as well in their study.

Table 3

Regression Analysis for Performance on Grade

Independent variable	Grade			
	Summer 99	Fall 98, Sect. 1	Fall 98, Sect. 2	Fall 98, Sect. 3
Constant	0.4000	0.3596	0.4595	0.4113
	(.0001)	(.0001)	(.0001)	(.0001)
Internet	0.0322	0.0021	0.0027	0.0066
	(.2441)	(.9223)	(.8882)	(.7248)
Gender	0.0469	0.0508	0.0305	0.0493
	(.0564)	(.0155)	(.1302)	(.0095)
GPA	0.1197	0.1347	0.1028	0.1173
	(.0001)	(.0001)	(.0001)	(.0001)
Regression Statistics				
Observations	71	75	106	97
R^2	0.41	0.48	0.29	0.41
Adjusted R^2	0.38	0.46	0.27	0.39
SE	0.0990	0.0846	0.0987	0.0869
F	15.23	22.22	14.20	21.21

Note: Parentheses contain *p* values.

These regression results provide little support for the contention that Internet technologies lead to a significant improvement in learning.

As a test of the robustness of these results, a separate set of regressions was run using an alternative dependent variable for Grade. Instead of using the weighted average that they scored in the class (theoretically a number between 0% and 100%), the students' letter grade was a used as the dependent variable (A = 5, B = 4, ..., F = 1). In all four

cases the results were virtually identical to Table 3 with respect to significance of the three dependent variables, even down to the level of significance. Moreover, the results with respect to the *coefficients* on Internet were even worse. For Fall 1998, Sections 2 and 3, the coefficient was actually negative. This implies that students were actually made *worse off* in the presence of the technologies. Of course the lack of statistical significance means these results should be interpreted with skepticism.

Table 5

Student Perception of Instructor Effectiveness (Summer 1999 and Fall 1998, Section 1 v Fall 1997)

SOS Mean Score (1 = Strongly Disagree, 5 = Strongly Agree)

Instructor Evaluation Statement	Summer 99 (n = 16)	F98, Sect. 1 (n = 18)	Fall 97 (n = 41)
1 Instructor is interested in the progress of the students.	4.714	4.222	3.854
2 Presentation of the subject matter is effectively organized.	4.572	4.278	4.000
3 The pace of the course was manageable.	3.714	3.389	3.585
4 The instructor communicates knowledge of the subject matter.	3.917	3.833	3.707
5 Course objectives were presented and understood.	4.214	3.722	3.829
6 The instructor is willing and able to help me.	4.500	4.500	4.146
7 The instructor is fair.	4.214	4.278	4.122
8 Instructional techniques aided understanding of course content.	4.000	3.667	3.610
9 Computer projects/exercises helped me to better understand course content.	3.857	3.533	3.067

Table 6

Student Perception of Instructor Effectiveness (Fall 1998, Sections 2 and 3 v Fall 1997)

SOS Mean Score (1 = Strongly Disagree, 5 = Strongly Agree)

Instructor Evaluation Statement	F98, Sect. 2 (n = 33)	F98, Sect. 3 (n = 25)	Fall 97 (n = 41)
1 Instructor is interested in the progress of the students.	4.152	4.200	3.854
2 Presentation of the subject matter is effectively organized.	4.303	4.160	4.000
3 The pace of the course was manageable.	3.939	3.920	3.585
4 The instructor communicates knowledge of the subject matter.	4.273	3.880	3.707
5 Course objectives were presented and understood.	4.182	3.960	3.829
6 The instructor is willing and able to help me.	4.576	4.200	4.146
7 The instructor is fair.	4.406	4.160	4.122
8 Instructional techniques aided understanding of course content.	3.939	4.040	3.610
9 Computer projects/exercises helped me to better understand course content.	3.781	3.958	3.067

The results of the test of the effect of the technologies on instructor evaluations are presented in Tables 5 - 7. Tables 5 and 6 present the SOS Mean Scores actually received by the instructor. Fall 1997 is included in both tables for comparison. Table 6

is particularly interesting, as there are substantial differences for some statements between Sections 2 and 3 even though the level of technology employed in both sections was identical.

Table 7 depicts the results of *t* tests of the difference between the Internet group's SOS mean score for a given statement and that of the Fall 1997 control group. The questions are removed from this table for ease of viewing. The question numbers correspond with the numbers at the far left of Tables 5 and 6.

Table 7

Student Perception of Instructor Effectiveness (*t* Test of Differences in Two Means)

	Summer 99		Fall 98, Section 1		Fall 98, Section 2		Fall 98, Section 3	
	Difference[a]	*p*[b]	Difference[a]	*p*[b]	Difference[a]	*p*[b]	Difference[a]	*p*[b]
1	0.860	0.0001	0.368	0.0607	0.298	0.1260	0.346	0.0573
2	0.572	0.0058	0.278	0.1531	0.303	0.1199	0.160	0.3739
3	0.129	0.7198	*-0.196*	0.5673	0.354	0.0701	0.335	0.0654
4	0.210	0.5602	0.126	0.7126	0.566	0.0044	0.173	0.3366
5	0.385	0.2902	*-0.107*	0.7543	0.353	0.0708	0.131	0.4661
6	0.354	0.3298	0.354	0.0708	0.43	0.0286	0.054	0.7635
7	0.092	0.7979	0.156	0.6485	0.284	0.1445	0.038	0.8323
8	0.390	0.2841	0.057	0.8675	0.329	0.0917	0.430	0.0190
9	0.790	0.0002	0.466	0.0188	0.714	0.0004	0.891	0.0001

[a] Difference between technology group mean and control group (Fall 1997) mean.

[b] *p* value associated with *t* test for testing difference = 0.

Italics indicate SOS mean scores that were lower for the Internet (et al.) technology group than for the control group. As is evident, only on two questions in the Fall 1998, Section 1 course were the evaluations actually lower than the Fall 1997 course. In all other cases, the evaluations were higher for the technology-enhanced courses. However, the significance of these results is not as strong as was found in Agarwal and Day (1998).

However, in response to the last question (question 9), where the students are asked to assess whether computer technology enhanced their understanding of course content, the difference is consistently significant at the 95% confidence level (and at the 99% confidence level for courses except Fall 1998, Section 1). This is surprising in light of the regression analysis, which found almost no *empirical* support for the contention

that computer technology has a significant effect (positive or negative) on learning. There appears to be a distinct *perception* among the students that technology, at least as applied to assignments, improves understanding of course content nonetheless.

It should be noted however that these results are strongly influenced by the small sample sizes of the courses. The Fall 1997 course had 53 students, of which 41 students completed the SOS survey in the last week of the course. The Fall 1998 sections had 18, 53, and 44 students of which 18, 33 and 25 completed the SOS survey in Sections 1, 2 and 3, respectively. The Summer 1999 course had 18 students (after two withdrew as mentioned above), of which 16 students completed the SOS survey. These small sample sizes, especially for Fall 1998 Section 1 and Summer 1999 may help explain the general lack of significance of the results in this section.

The statistical calculations presented above were made in an effort to provide some level of empirical measurement and are presented for interest only. It would be inappropriate to apply too much weight to the statistical results presented here.

V. Conclusion

Upon attending Robert Morris College's eleventh annual conference on "Teaching Economics: Instruction and Classroom Based Research" this February, it was obvious that two areas have taken center stage as a focus of professional effort in the teaching of economics: technology and active learning strategies. Although, technology was not explicitly listed as a central theme of the conference, it was discussed with great interest by the participants at a keynote address by Peter Navarro (with regard to the CD-ROM courseware developed at the University of California - Irvine under his direction) and in approximately half of the sessions attended by this author, whether technology was explicitly the topic or not.

However, the other half of the sessions were devoted to what makes use of technology successful--the active participation of the students in their studies. I believe that the explanation for the weakness of the statistical analysis above, especially in regard to the larger classes where statistical significance would be more likely to be detected, must lie in the rather low priority active learning has had in the classroom.

It is not an easy admission to make, as I pride myself on being an interesting, sometimes entertaining, and occasionally even insightful instructor. I believe the

evaluations I received reflect this. The students know I am unwilling to sacrifice rigor for fun, as indicated by the relatively lower "The pace of the course is manageable" and "The instructor communicates knowledge of the subject matter" results. (Indeed, a student once commented on the SOS that the instructor was "overeducated" for the course.) However, the students also soon realize that they can come to my office at any time to ask me questions (as indicated by the relatively higher "The instructor is willing and able to help me" results), that I am interested in their progress throughout the course, and that I will act in a fair and unbiased manner in regard to the class and their individual performance. Thus, I have focused my energies in the area central to the institution's mission and have sought out ways to make use of technology in the teaching of economics.

However, the quest to improve the technological level of the course has not been balanced by examining ways to improve students learning outcomes in the course. Technology cannot turn a "C" student into an "A" student in economics by itself. The emphasis in the literature, as is especially obvious in the Journal of Economic Education, is that both technology and active learning strategies raise the success rate of students in a course. Student-to-student interaction, whether it is by e-mail, unmediated discussion lists, instructor-mediated discussion boards, or chat rooms, adds an important dimension in achieving student involvement in their learning.

Students learn in a wide variety of ways, therefore a wider variety of approaches are more effective for promoting student and learning. Becker (1997), among others, emphasizes the importance of diverse learning styles based on the conclusion reached in Siegfried and Fels (1979): "Different students learn economics in different ways. The best teaching strategy provides alternative learning methods." (p. 953). Becker emphasizes two modes of instruction as recommended alternative techniques: Learning with group activities, such as the "think-pair-share" activity to provide an important break in a steady lecture stream, and learning with individual activities, such as the "minute paper." That this last activity is effectively employed using Internet technology by Chizmar and Walbert (1999) is evidence that active learning and extensive use of technology are not mutually exclusive teaching strategies, but instead can complement each other very successfully.

In the future, a greater concentration on active learning techniques should routinely accompany the use of technology. As students become more and more sophisticated in their use of computers, they will expect them to be employed in the classroom. However, whether the tool actually improves learning is completely dependent upon the way it is employed. If it acts merely as substitute for a "low technology" technique, there is no reason to expect any improvement any learning. If, on the other hand, the technology is introduced in a manner that facilitates the use of learning strategies that have been demonstrated to be more effective in promoting learning, then there is every reason to expect that the use of technology will be correlated with better learning outcomes. Of course, this is actually something of a spurious correlation, since the active learning techniques, made lower cost or more easily employed by the use of technology, are actually driving the improved learning outcomes. Future research should examine this hypothesis more closely.

This paper demonstrates that there are many ways to enhance an economics course using technology. In general, stronger students tend to better appreciate these methods and make better use of them. This may promote retention of those students in the program, but this hypothesis was beyond the scope of this paper. However, it is clear that the technology does not necessarily improve learning outcomes for the average student, even though there is weak evidence that it does lead to more positive results in end-of-semester evaluations. While some may argue that this justifies the use of technology, since student opinion surveys play a significant part in the evaluation of teaching by administration and therefore are of importance, I believe improving learning outcomes should be the primary goal of effective teaching. Therefore, further research that demonstrates the effective use of the technologies in combination with active learning strategies discussed herein could prove to be a profitable avenue of inquiry into the teaching of economics.

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