Offering CS1 On-Line

Reducing Campus Resource Demand While Improving the Learning Environment

Jon A. Preston
Department of Information Technology
Clayton College and State University
Morrow, GA 30260-0285
jonpreston@mail.clayton.edu

Laura Wilson
College of Computing
Georgia Institute of Technology
Atlanta, GA 30332-0280
lswilson@cc.gatech.edu

Abstract

Multimedia-rich Web interfaces offer an increasingly attractive option for teaching distance and large-scale courses. We explore our experience of publishing CS1 to over 200 students and the resulting student performance. Our approach included streaming QuickTime audio and video synchronized with animated PowerPoint slides; in addition, a "Frequently Asked Questions" (FAQ) list was compiled from previous students' questions and made available. We demonstrate that the on-line lecture material enhanced students' learning of those enrolled in the traditional, lecture-based sections and those enrolled in the on-line section. The process is cost-effective, scalable, and affords use in other disciplines beyond CS1. Our future research is also discussed.

Keywords

On-line learning, large-scale courses, CS1, distance education, streaming media, empirical analysis

1 Motivation

Our CS1 and CS2 courses have grown tremendously in the past seven years as we try and keep up with the frantic pace of demand for CS education. CS1 is part of the core curriculum for the university, and CS2 is required of most students as well. As a result, we teach approximately 5000 students each year in these two service courses.

Large lectures of 300 students are required in order to fulfill demand, but we feel that it is vital to provide students with as many opportunities to assess their knowledge as possible; thus we require either a homework or quiz each week and offer personalized attention for each student by way of teaching assistants. Such frequent assessment and personal attention result in a tremendous strain on the campus' computing labs and lecture hall resources.

We were completely occupying two of the five campus computer clusters from 8 am to 10 pm, five days a week. It became apparent that this model of "taking over the campus resources" was not sustainable, and we were asked to offer alternatives that would allow other students access to the computer clusters. In addition, we wanted to make use of the new campus-wide computer ownership policy; all students owned either a desktop or notebook computer with a common suite of software, so why not allow them to utilize their new investment!

2 The Optional "Lecture Anytime" Sections

Our solution to the problem of reducing our demand on campus resources is to offer optional "lecture anytime" sections for CS1 wherein students

- Complete the same homework assignments
- Take the same quizzes and final exam
- Have the same contact time with teaching assistants (minimum of 20 minutes per week) and the instructor (through office hours)
- Have the same access to course-related newsgroups and e-mail
- Have the option of attending another lecture section if desired (with no expectation or reward)

We refer to this option as "lecture anytime" because students may view the lecture at any time and on any computer connected to the Internet.

In order for the "lecture anytime" option to be viable to students' learning, we must ensure that the on-line materials were of sufficient quality. It is not enough to simply reduce demand on campus resources at the expense of students' learning; we must maintain (and hopefully

improve) the quality of education through the new medium [3].

Thus began the arduous task of creating and processing the material in preparation for offering the on-line option to students. In addition to making these resources available to our students, we agreed to publish our material to six other professors at institutions within the University System of Georgia. These professors are using the same textbook and teaching approach, and we wanted to leverage our efforts and help them improve the learning experience of their students. An added benefit is that we are able to get additional suggestions from other instructors and further improve the material in the future.

3 Setting the Stage

Creation of the on-line material was achieved during the summer and fall of 1999. This included improving the lecture slides, recording and processing the lecture content into video and audio streams, and installing a QuickTime server to host the material.

To date, the course material has been organized into 30 lectures. One of the first discoveries we made was to organize the material by topic rather than the artificial, forced organization by lecture. This resulted in a clearer picture of the course's content into 70 "knowledge units." It was then possible to focus on each of these units individually based upon their relative importance to the course as a whole [2].

3.1 Ensuring Quality

The existing set of mostly static PowerPoint slides were improved; animations of algorithms and data structure manipulations were added. The result was a set of over 1500 high-quality lecture slides compiled by over six different instructors.

An instructor went into studio twice a week to record lecture material for a total of over 50 hours of studio time. Using chromakey (similar to the "weatherman approach"), the instructor was superimposed onto the PowerPoint slides. The instructor lectured to the camera, animating the slides and highlighting concepts as needed. After the first pass in the studio, another instructor reviewed each segment to ensure quality control. This reviewer created a list of mistakes, blunders, and suggested improvements for each segment. The majority of the 70 segments recorded were redone in studio after many improvements were made to the slides and the "script." The result was over 20 hours of quality content.

3.2 Choosing a Streaming Media

As the audio and video materials were being generated in studio, we examined many streaming media server suites. We decided upon a QuickTime server on a Power Macintosh G3 running OS X. This decision was based upon Macintosh's reputation, demonstrations of the QuickTime server's performance, cost, and available support personnel. RealAudio was ruled out because of the price scheme – a per-stream cost was prohibitive since we wanted to offer potentially hundreds of simultaneous streams. QuickTime seemed the best approach because it is capable of handling up to 2000 streams at 28.8k and comes pre-installed on the Macintosh OS X [1]. The cost of the equipment for the project came to approximately $19,000; this price included the streaming server, a Macintosh for video processing, and a digital video deck to input the recorded video into the processing machine. At today's prices, comparable machines should cost approximately $11,000.

By January of 2000, we had all of the components in place to offer the "lecture anytime" section of our CS1 course.

4 Enrollment

We offered the option of taking the course in the "lecture anytime" section to all students. The only requirement established was that the student could not be a first-semester student at Georgia Tech for fear that the student might not be acclimated to the university and place themselves at risk of academic failure in a "trial" version of the course.

An announcement was made within the registration system that directed students to an information page on the Web explaining the "rules of the road" for the "lecture anytime" section. The students were to follow a checklist to verify that their computer could play the streaming audio and video and sign that they agreed to try out this "experimental" section of CS1. Once the student filled out the electronic "permission form," we granted permission for the student to take the "lecture anytime" version of the course. Thus, theoretically, we guaranteed that all students knew what to expect before enrolling in the experimental section.

Total enrollment in the "lecture anytime" section of the course was over 200 students. Students from many different majors (CS and non-CS) and different class standing (from freshman to senior) enrolled in the experimental section. These students represented 15% of the total student enrollment for the term.

5 Results

We assess the success of the project via objective and subjective measures. We examined student performance on homework, quizzes, lab projects, and the final exam. We also performed log-file analysis to determine weekly utilization of the on-line materials. To subjectively measure the students' experiences, we had students fill out an anonymous survey at the end of the semester.

5.1 Objective Results

The objective data indicates that students made use of the on-line material extensively throughout the semester. Performance was comparable between the control group and the experimental group.

5.1.1 Material Utilization

As one might expect, the highest utilization of the on-line materials occurs the day before an assignment was due or quiz was given.

During a fifteen-week semester, over 10,000 video sessions (streams) were served.

Over 600 students made use of the on-line media, distinct viewers based upon client IP address (assuming a 10% factor of error due to logins from multiple machines based upon survey results).

The average length that a student watches a video segment is 8.5 minutes.

The average total viewing time of material by students for the entire term is 10 hours (of a possible 20 hours available). When the use of material by the traditional, lecture-based student group (control group) is factored in, this result indicates that the average "lecture anytime" student viewed 66% (13 hours) of the lecture material during the semester.

5.1.2 Student Performance

Figure 1 shows the relative student performance of the experimental and control group for each measure in the course.

Overall, the experimental and control groups performed comparably, with the experimental group performing only slightly worse in most areas of performance assessment. The average deviation overall was approximately 2.5%.

The final exam marks the experimental group's most notable deviation from the control group; the "lecture anytime" group performed 6% lower than the control group. This higher deviation may be explained by the fact that three different versions of the final exam are used during the weeklong final exam period, each of which has a slightly different difficulty. While we make every effort to create exams of comparable difficulty, post-semester analysis of the final exam grades demonstrated that the final exam given to the "lecture anytime" students was more difficult. Because each version of the exam is given to two sections of students, we are able to more accurately compare the performance of the experimental section. When correlated to the performance of a control group taking the same, more difficult exam, the experimental section performed less than 1% worse than the control group on the final exam assessment.

This demonstrates that the maximum deviation on any assessment between the control and experimental sections of students is less than 4%.

	Home work	Quiz	Project	Lab Midterm	Lab Final	Final Exam	Overall
Lecture Anytime	80.7	70.99	86.14	70.19	75.13	51.3	69.79
Control	82.43	74.48	86.72	67.37	77.59	57.26	72.28

Figure 1 - Student Performance Comparison

5.2 Subjective Results

The subjective data indicates that most students were pleased with their on-line learning experience. 51 of the 200 students completed the survey at the end of the term.

When asked to rate their experience with the "lecture anytime" course on a scale of 1-5 (5 being the best), the average response was 3.9.

78% of the respondents stated that they would take the "lecture anytime" version of the course again.

53% of the respondents state that they felt that their grade was helped as a result of taking the "lecture anytime" section, while 37% state that they felt that their grade was hurt as a result of taking the "lecture anytime" section. Of those students who report that their grade suffered, 54% report they would take the "lecture anytime" section of the course again.

20% of the respondents report attending the traditional lectures at some point during the semester.

Some typical students' free responses include:

> "Lecture anytime was helpful for me because I am a student that sometimes misses lecture and don't always understand things the first time they are taught to me, so the ability to watch them multiple times was truly beneficial to me. I would certainly take lecture anytime again. In fact if there were a choice between two classes and only one was lecture anytime, that would weigh into my decision on which class to take."
>
> "Sometimes I forget about the whole class, because it's not mandatory."
>
> "I was irresponsible at the beginning of the semester with the videos. I didn't realize how much they really helped me understand the concepts. I didn't keep up with them until later in the semester…"
>
> "My self discipline collapsed after a week of online lecture, so I just started attending lectures on a regular basis."

6 Conclusions

The results of this study indicate that offering on-line material for CS1 can increase the options for students taking the course without degrading the educational experience. We serviced 15% of the students enrolled in the "lecture anytime" section, reducing on-campus demand for lecture hall and computer lab resources.

An added benefit of this project is that we have supplemented the existing, lecture-based course with enhanced lecture slides, supplemental audio and video for students to review, and a FAQ list. This serves to benefit the entire student population.

6.1 Performance Analysis

The results of the study indicate that students in the "lecture anytime" section are able to do as well as students in the control group. The objective performance deviation of the experimental group is 2.49% lower than the control group despite the lack of mandatory, physical lecture attendance and an increase in self-reported lack of self-discipline to keep up with the lecture material. This indicates that students in the "lecture anytime" section performed only slightly worse than the control group.

It might be expected that a self-selecting group of students would be more motivated in a "lecture anytime" version of the course and thus the lack of an increase in overall grades might indicate a problem. We acknowledge this to be a concern and plan on working to improve the student-teacher interaction to facilitate a more sustained student involvement with the course. We note that many students informed us of their lack of self-discipline, and we hope to help them overcome this problem in the future.

We expect that with better communication of course expectations and accountability to encourage students to view the material that student performance in the "lecture anytime" section will improve.

6.2 Servicing Students Better

We found that there are significant hurdles to overcome when allowing students to enroll in an on-line section of the course. The course content was sufficient, but majority of the problems resulted from difficulties with the technology.

First, there was an issue of installing the correct version of the QuickTime player on student and campus machines. There was a mistake in the installation on campus that resulted in problems for students. In addition, some students were unsure how to download the correct (free) version of the QuickTime player. As a result, we have increased the detail of the instructions that students follow to set up their computers for the course.

Second, it became apparent to us that students had enrolled in the on-line section of the course without verifying that their computers could handle the streaming media. This put us in a difficult situation – not wanting to compromise the educational experience while still allowing the students to participate in the on-line section. Approximately 10% of the students in the on-line section did not have sufficient Internet bandwidth to handle the streaming media. To compensate, we copied the material onto CD-Rom for these students so that they could continue to watch the material. This was quite time-consuming since the material consumed 10 CD-Roms!

Third, the size of the streaming media was hindering the educational experience of students. We had originally compressed the video at full-screen, 640x480, Ethernet bandwidth. While this seemed the best route given that

students were required to have fast Internet connections, we found that many students wanted to watch the video from off-campus. We also had problems with degraded video quality. As a result, we recompressed the video and audio into a modem-friendly 28.8k rate of 160x120 to serve the students' needs better. The thumbnail-style video provides the appropriate context of what the lecturer is discussing, and the synchronized PowerPoint slides were made to occupy the majority of the screen. The learning environment was improved, and network bandwidth requirements were reduced, opening the on-line material to off-campus students. Also, the material now fits onto one CD-Rom, affording an additional cost savings if we need to distribute the material using CD-Rom.

7 Future Research

Given the spring semester's success, we offered the "lecture anytime" option again during the summer term. 40 students, 20% of the total enrollment summer term, took the course on-line, and we have seen similar, impressive results.

We are currently re-recording the lecture segments for a third time with another instructor in an effort to further enhance the material. We plan to offer both instructors' material on-line so students have multiple views of the same lecture material.

In addition, we are incorporating more of the students' questions into the FAQ and integrating this supplemental, detail-level information directly into the "lecture anytime" interface. Figure 2 gives a sample layout of the new user interface; note the FAQ links at the bottom of the window.

We also plan to incorporate concept-mapping tools to offer students an overview of how concepts in the course relate to each other. This view of the course material will allow students to easily hyperlink from one topic to a related topic; for example, a student studying parameter passing might link to a related topic on variable scooping for more information.

We will continue to offer the "lecture anytime" section and expand the learning resources made available to on-line and traditional students. We would like to increase the enrollment in the on-line section, but will always leave the decision to the student as to what is best for their learning style.

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References

[1] Apple's New QuickTime Streaming Server Doubles Performance, 1999. Online. Internet. [July 7, 1999]. Available WWW: http://www.apple.com/pr/library/1999/jul/07qt.html

[2] Romiszowski, A J. *Developing Auto-Instructional Materials*. Kogan Page, London. (1999).

[3] Teaching at an Internet Distance: the Pedagogy of Online Teaching and Learning, 1999. Online. Internet. Available WWW: http://www.vpaa.uillinios.edu/eid/report/tid-final-12-5.doc

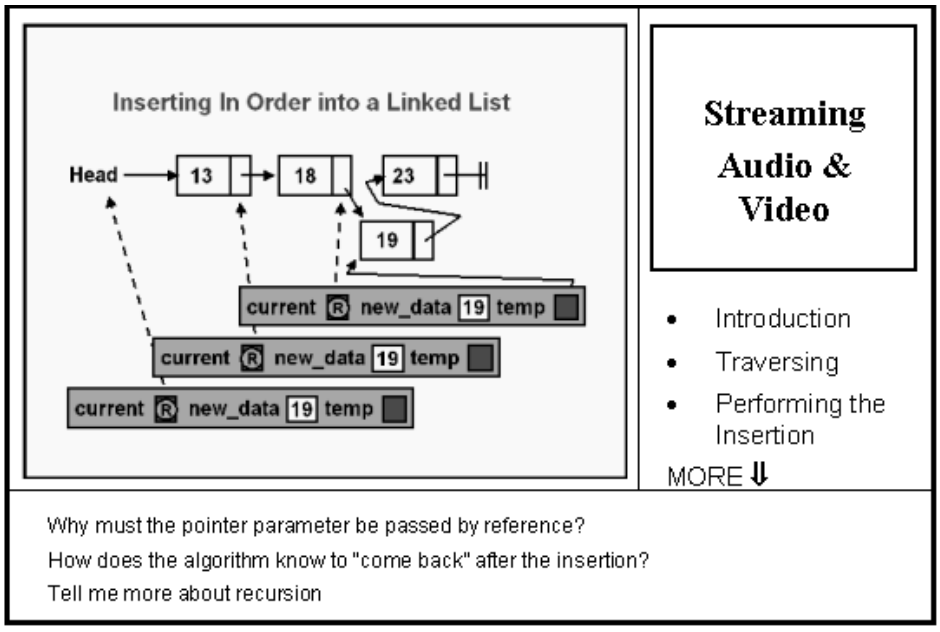

Figure 2 – Improved User Interface for Students