Tablet PC Video based Hybrid Coursework in Computer Science: Report from a Pilot Project

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ABSTRACT

Online learning, defined broadly as recording and delivering classroom experience with technology, has tremendous potential. However, success to date has been very limited in science and engineering. We believe this is because traditional video recording is cumbersome and not suitable for technical lectures and removing live classroom interaction is detrimental to learning. Employing Tablet PCs with slide presentation software has made it simple and convenient to develop and record high quality lectures. We employ such videos in a hybrid model of coursework. All lectures are made available as online videos, but limited classroom interaction is an important component; the classroom is used for review of lecture material, examinations, demonstrations, tutorials, and hands-on sessions. The hybrid framework is particularly suitable for students with logistical difficulties, e.g., because of work schedule. This paper is an evaluation of the hybrid learning approach as applied to upper level computer science coursework. We report our experience in teaching a suite of hybrid courses at the University of Houston and discuss the detailed feedback we received from the students who participated in the courses.

Categories and Subject Descriptors

K.3 [**Computers and Education**]: General

General Terms

Measurement, Design, Experimentation, Human Factors

Keywords

Hybrid learning, Online learning, Video lectures, Tablet PC

1. INTRODUCTION

Emerging technologies to deliver coursework have tremendous potential to improve the education experience and make it more flexible. However, traditional distance learning has met with limited success to date, especially in science and engineering. University of Houston has enrollments in distance education programs approaching 10,000 in a student body of approximately 35,000. However, a very small fraction of this enrollment is in science and engineering. The appeal, deployment and success of distance learning has been very limited in computer science, despite an evident need for such technology. A large fraction of students in computer science at UH have part-time or full-time jobs and can benefit from more convenient and flexible courses. Further, there is a significant demand for some computer science courses among IT professionals. In fact, some of our faculty teach courses similar to our curriculum courses at local corporations on a regular basis.

Several studies have revealed the strength and weaknesses of various distance learning methodologies. Evidence of the importance of having face to face classes in distance education courses has been recorded in [5, 8]. Hybrid courses that employ a combination of classroom and electronic material have been employed to overcome some of the limitations [6]. However, there are few published experience reports for Computer Science (and similar fields). While some of the discussion of distance learning spans across subject areas, there are other aspects that are field-specific. We limit discussion in this paper to computer science coursework.

In our view, there are two fundamental reasons for the limited success of distance learning in science and engineering. We discuss these as follows:

Limitations of distance learning model: Classroom interaction between the students and the instructor, and among students, is critical for learning. Hence a traditional online/video distance learning approach is restrictive and often used only by students who simply cannot attend classes.

Limitations of course delivery mechanisms: The common delivery mechanisms for distance learning at UH (and elsewhere), are web based delivery of textual and graphical content and video delivery. We explain these briefly:

Web-based delivery: This model typically involves posting lecture notes, and other material on a web site, often supported by chat room type interaction under the control of an e-learning management system like WebCT. While this has substantial value, live classroom interaction, illustrations and discussions are not delivered, which is a crucial limitation.

Video delivery: Lectures are recorded with a video camera and broadcast on special cable TV channels or made available on videotapes or other media. While this model is adequate for many subject areas, we believe it is not a

good match for scientific lecture material for the following reasons: First, projected overheads with details are not captured well. Second, illustrations have to be made on a separate platform and the instructor finds it difficult to go back and forth between overheads and illustrations. We believe these are the reasons video delivered courses are more popular in, e.g., business and law, than in computer science. Finally, one person is needed for manning the camera, increasing the cost of deployment.

This paper reports our experience with a "hybrid" model for Computer Science courses. This hybrid model has the following key features:

1. Lectures are recorded with Tablet PCs in a live class and made available to students in hybrid sections with internet streaming. This largely overcomes the problems with camera based video.

2. There is a strong emphasis on the relatively small number of face to face classroom sessions that are mandatory. There is regular, albeit less frequent, instructor-student and student-student contact and the social environment for learning is maintained.

The broad objective of this project is to get the best of both worlds: Technology is applied to develop high quality lecture material that students can access at their own convenience. At the same time, all components of teaching for which human interaction is beneficial, are done in the classroom.

This paper reports on faculty and student experience in teaching a suite of hybrid courses. We discuss the benefits and limitations of the hybrid approach, report on how it changed the education experience of the students, and discuss how it can be improved.

2. HYBRID COURSE STRUCTURE

A hybrid course in our framework would have the bulk of the classroom lectures available online, but regular, although infrequent, classroom meetings are mandatory. In most instances, a *hybrid section* is taught concurrently with a regular *classroom section*. All lectures from the classroom section are recorded and posted online immediately. These lectures are the primary access to the classroom discussion for hybrid section students, but they also serve as supplementary material for all students in the class. We have also taught pure hybrid courses with no concurrent classroom section. In this case, the online lecture material is either based on a previous semester or is recorded by the instructor outside of the class.

2.1 Lecture recording and delivery

The basic content of a hybrid course consists of recorded classroom lectures made available on the web as streaming videos. Typically the instructor prepares a lecture as a set of (Powerpoint) overheads and employs the Tablet PC for teaching. The instructor can add annotations during a lecture by writing directly on the Tablet PC screen with an electronic pen. This approach to teaching is becoming popular as it freely mixes prepared content with hand illustrations and has been discussed in [3, 4]. We employed the Classroom Presenter [1] from the University of Washington for teaching with a Tablet PC and found the writing experience very natural. A system called the Ubiquitous Presenter with new enhancements has been discussed in [7].

The entire lecture is recorded on the Tablet PC itself. The audio consisting of instructor's speech, including questions from the students in the class, is fed into the Tablet PC through one or more microphones. Off the shelf software –we used Camtasia and Camstudio for this purpose– is employed to record the computer screen and the audio as a video file. The lectures are then made available to the students as streaming video, employing the VNET content management system developed at the University of Houston and the University of Puerto Rico [2]. The students in a hybrid class can access the lectures at their own convenience and proceed interactively at their own pace. The students can stream the lectures directly, or download the lectures and play them on their machine. Currently a lecture is a single video file, but in the future they will be indexed allowing the students to jump to specific topics.

2.2 Hybrid organization

Classroom interaction remains an important component of the course for hybrid classes. Course content is divided into *modules*, with a semester long course typically consisting of 4 to 8 modules. Students in hybrid sections typically have one classroom meeting per module with additional classroom meetings as needed. Class time is utilized for activities for which direct personal interaction is important. Examples include addressing student questions about video lectures, discussions that center around student participation, discussion of current research topics, descriptions of projects and assignments, show and tell demonstrations, and field trips. All examinations, quizzes and project demonstrations are in the classroom or at designated locations. The best frequency and duration of the classroom meetings is an open topic and will vary among courses. We are developing some guidelines in this regard as a part of this project.

3. EXPERIENCE AND RESULTS

The hybrid framework was employed to teach 3 different courses; *Introduction to Computer Networks*, *Interactive Computer Graphics*, and *Software Engineering*. All of these are senior level undergraduate courses. The courses on computer networks and computer graphics have been taught twice with the hybrid framework and additional courses are currently being taught. The class sizes for these were relatively small and the total enrollment in all these courses was approximately 50. At the end of each semester, the students were invited to discuss the class organization with the instructor. They were also asked to fill out a questionnaire to evaluate the hybrid framework. The questions focused on the technology employed for online lectures, the hybrid model and how it affected the learning experience, and suggestions for improvement. We discuss the key points from student evaluations and discussions, along with the experience of the instructors.

3.1 General observations

Our goal is to employ the hybrid model to provide flexibility to students without impacting, and perhaps even improving, their educational experience. The instructors did not notice any significant difference in the grades achieved and dropout rates for hybrid and regular students, although there is not enough data to make a conclusive judgment.

When a hybrid class was taught as a separate section of the regular class, students in all sections were free to attend

regular lectures in the class or receive the same lectures on-line. While no attendance records were kept and the pattern varied across classes, typically a quarter to over half of the enrolled students would attend a given lecture. Approximately 20-30 percent of the classes were mandatory and virtually every student would attend those classes.

3.2 Tablet PC based videos

The students were queried about the quality and availability of video lectures recorded on Tablet PCs. As shown in Figure 1, virtually all students considered the video quality of lectures to be acceptable, while around 40% rated them as very good or excellent. The variation in this subjective perception of quality may be related to the medium on which the lectures were viewed which can vary from an iPod to a high quality monitor. Student responses to other questions not plotted in this paper indicated that video failure for technical reasons did happen but was rare.
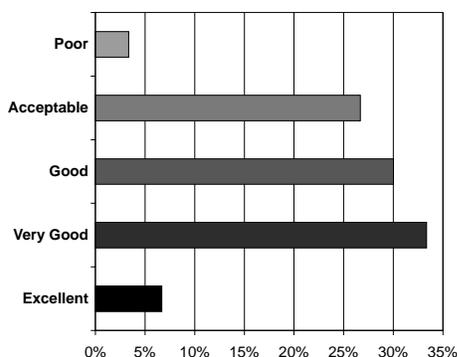

Figure 1: Student responses to the question: *What is your impression of the video quality of the online lectures in the class?*

Students had the choice of watching a class video by direct streaming or by downloading on their computer and playing locally. Direct streaming has the advantage that video watching can begin almost immediately without waiting for a download to complete. The download time can be significant for a full lecture video depending on the internet connection and the load on the streaming server. However, downloading first and watching has the advantage that the video can be watched independent of the quality or existence of the internet connection, which is particularly relevant for mobile users. Further, streaming worked only for Windows and Mac users, while downloading was the only option for Linux users. Figure 2 shows that both download and streaming modes were used extensively. Just under a quarter of respondents employed downloading exclusively, a similar number employed streaming exclusively, and the remaining employed both to varying degrees.

3.3 Hybrid format

The students were queried to understand how they were learning and studying with the hybrid option. One of the concerns of any distance learning based approach is that it encourages procrastination. However, almost all the students said that they would view the lecture videos within a week, based on responses tabulated in Figure 3. Perhaps
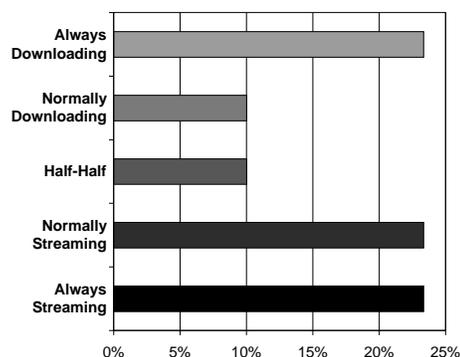

Figure 2: Student responses to the question: *Did you normally use the video lectures by direct streaming from the server, or by downloading first and watching on your machine?*

this is not surprising given that all the courses included regular assignments and quizzes that required a knowledge of the lecture material.
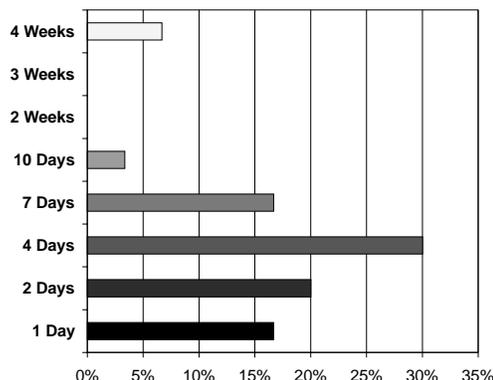

Figure 3: Student responses to the question: *On average, when would you view the video lecture after the class for the first time if you did not attend the class?*

An interesting aspect of making video lectures available to students is the impact on study habits. Almost all students said that they viewed the video lectures as part of preparation even if they attended the corresponding class. Figure 4 charts how the student dependence on the textbooks was affected with the availability of video lectures. Approximately 80% of students made less use of the textbooks to varying degrees since video lectures were available. Figure 5 shows the strategies employed for preparing for examinations. Around 65% of the students employed a combination of the textbook and video lectures, while around 20% primarily used video lectures, and only 7% primarily used the textbook.

In several of our classes, the students were free to attend live classes or view video lectures on their own. In order to gauge the value the students attached to the video lectures, they were asked if they would prefer to have normal full classroom access but no access to video lectures, or full access to video lectures but no access to the classroom. The
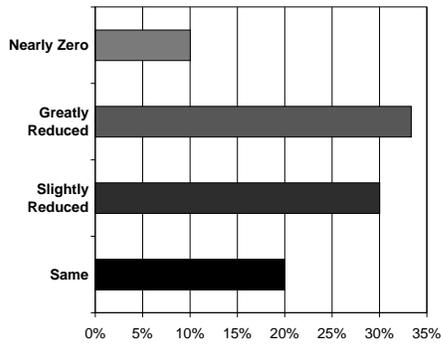
Figure 4: **Student responses to the following question:** *As compared to the time you would probably spend if video lectures were not available, the time you spent studying the textbook was ?*
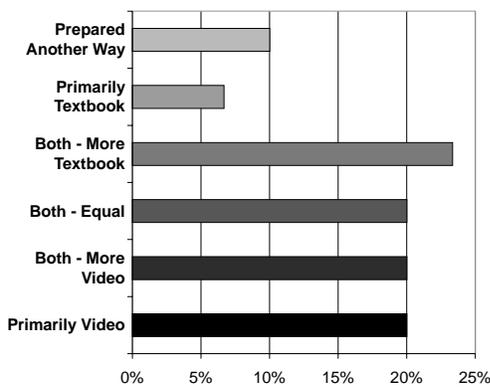

Figure 5: **Student responses to the following question:** *How did you prepare for the mid-term and final exams ?*

results are plotted in Figure 6. Students were almost evenly divided in their preference for classroom access only or video lectures only, with a few students with no preference. However, around 27% of the students responded that they would definitely prefer video lectures, while only 10% of the students responded that they would definitely prefer classroom access.

3.4 Future improvements

The framework for hybrid coursework can be improved in a number of ways. We queried the students on the value of the following features if they were made available:

- **Instructor in video:** Currently the videos are based on the screenshots of a Tablet PC. This proposed feature would involve adding a camera and including the instructor in the video, possibly in a separate box.

- **Indexed videos:** The videos would come with index snapshots where a new topic or subtopic was started. The students can skip directly to any index point in the video lecture with a simple click.

- **Live webcast:** This would allow the classes to be webcast live. The students could tune into the class
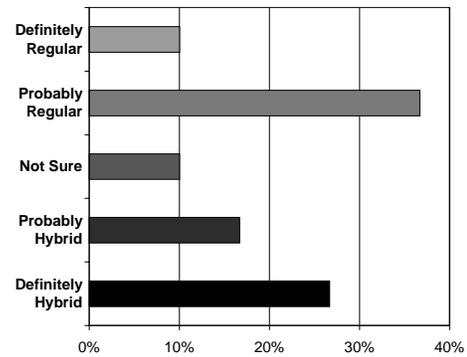

Figure 6: **Student responses to the question:** *Suppose you had to strictly pick one or the other format for this class: If you picked Hybrid, you would not be allowed to attend classes and if you picked Regular, you would not have access to video lectures. What format would you pick ?*

remotely and even type in questions for the instructor in real-time.

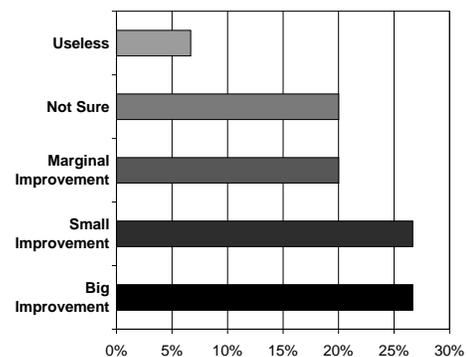The students responses to these features is charted in Figures 7, 8, and 9.

Figure 7: **Student responses to the question:** *Suppose the online lectures also included a video of the instructor teaching the class. This would be ?*

The data shows that an overwhelming majority of students believe that adding indexing to videos will be a big improvement, while the level of enthusiasm for webcasting and having the instructor in the videos is limited. The chief appeal of the hybrid model is that the students can view the lectures at their own convenience which may explain the rather limited support for live webcast. The presence of instructor in the video primarily has psychological value since relevant speech and actions are captured by the table PC, which may explain the relative uncertainty of the value of this feature. Indexing has the obvious appeal that students can quickly move to the topics they want to learn or with which they are having difficulty. One of the most frustrating aspects of learning from videos is searching for the parts that hold the content that is of interest. Our ongoing research is addressing automatic indexing of lecture videos.
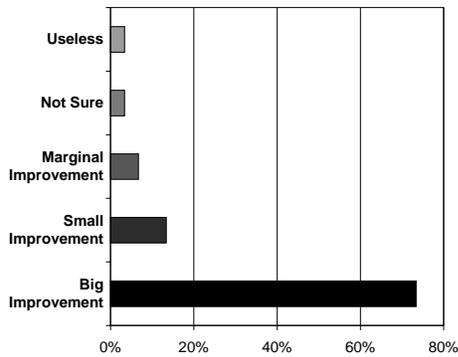
Figure 8: Student responses to the question: *Suppose the online videos came with an index: each index point is a snapshot in the video where a new concept in the lecture is started. This would be ?*
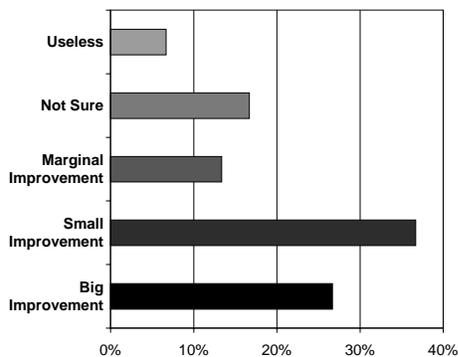

Figure 9: Student responses to the question: *Suppose the classes were webcast live - you could listen to them and even type in questions for the instructor in real-time. This would be ?*

4. CONCLUSIONS

This project is developing hybrid coursework that combines Tablet PC based recorded lectures with limited classroom interaction. The paper reports on a total of five course offerings of three different courses at the upper undergraduate level. Some conclusions that can be drawn from the survey results are presented as follows:

- Tablet PCs offer an excellent way to record and deliver classroom experience for computer science courses. It is important to support video streaming to make video lectures available to students.

- The students consider video lectures a critical resource, on par with a live class. Also, video lectures naturally become an important component, along with textbooks and class notes, for learning and preparation for examinations, irrespective of whether a student attends classes or not.

- Partitioning and indexing of video lectures into meaningful topics is of great value.

Rapidly improving instructional technologies will almost certainly change the structure of teaching and learning in

years to come. However the models in which technology will be employed to facilitate and enhance coursework is far from clear. This project is an attempt to provide "anywhere anytime" learning flexibility to students without losing the benefits of classroom interaction. The goals of this project include reducing time to graduation and increasing enrollments by providing flexibility. We consider the project to be a success and the model has become popular among faculty and students in our institution. A number of other courses will be offered as hybrids in semesters to come. However, many questions remain, e.g., what should be the number of mandatory classes in a hybrid course? what should it depend on? what should be covered in the mandatory classes? etc. One of the goals of this paper is to help form a community to address these challenges together.

5. ACKNOWLEDGMENTS

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