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#ITP4345

A Comparative Efficiency Study Between a Live Lecture and a Web Based Live-Switched Multi-Camera Streaming Video Distance Learning Instructional Unit

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ABSTRACT

This paper details the implementation of a comparative experiment which probes the issue of learning effectiveness vs. absolute amount of learning attained in a web environment, by comparing performance between traditional face-to-face delivered instruction and instruction delivered via distance technology using an asynchronous live-switched multi-camera stream composed of audio, video, and accompanying PowerPoint presentation via the Web. By capitalizing on the latest technological advances in the field of streaming video, the authors implement a method for conducting web based education at a quality normally associated only with dedicated proprietary gear, but in a more economical manner. The net result is a method for conducting high-quality web-based education that is more efficient. The authors provide data to validate the method employed.

INTRODUCTION

The use of technology for distance learning and training is growing at an astronomical rate. As organizations, both in the private and educational sectors, have subscribed to erecting intranets, it has made it economical to use this as a vehicle for training. The Yankee Group tells us by the year 2002 corporations will spend 44 billion dollars on web related services [1]. Analysts at Forester Research, tell us that two-thirds of Fortune 500 companies already have or are planning Intranets [2]. "The catalyst for the rise of Web based training is the increasing need for corporate training, particularly in the area of technology. Whenever a company upgrades its OS, e-mail package, or word-processing application, the staff must be trained" [3].

The increased availability in bandwidth combined with the infrastructure provided by the Internet and corporate intranets have enabled the use of this technology for training purposes. Sun has reported that by using technology based training it expects to cut its sales training cost by as much as 50 percent [4]. GTE estimates that prior to putting its classes on-line, it spent approximately $7,000.00 per student sent to Northern Telecom for training. This cost has been reduced significantly. Ellen Julian from Montgomery Securities tells us the $16 billion world market for tech training will hit $28 billion in the year 2001.

The need for distance learning solutions has not been restricted to private companies in need of well-trained employees. Higher education institutions have also taken an active interest in distance learning technologies. "Columbia University decided to jump on the online instructional market and to further that end the school hired Ann Kirschner – once a Princeton University English professor – away from NFL.com … her goal is to put the university's core content onto the Internet and to charge users a fee for it." [5]. Kenneth Clow tells us "students are now able to earn business degrees without even setting for on an actual college campus." [6] The same is true for law degrees. Concord University offers a Doctorate of Jurisprudence entirely over the web. [7] Accreditation is also being addressed. "Harcourt General may become the first major publishing house to offer accredited college degrees [on-line], pending approval from the New England Association of Schools and Colleges."[5]

Distance learning solutions range, on the high-end, from multi-thousand dollar set-ups capable of synchronously streaming multiple streams of broadcast quality video, to low-end solutions, requiring nothing more than a few web documents with accompanying video clips housed on a free web server such as Apache. With the wide range of capabilities and cost-entry points available, the authors decided to survey the existing distance learning topology and then to implement a solution that would deliver a considerable amount of learning at an entry-level price point. By capitalizing on recent advancements in the field streaming media, the authors thought it would be possible to implement a system that achieved a relatively high level of raw learning without the expense of a proprietary solution. The net effect would be a system with a high degree of learning efficiency.

Keeping their focus on the implementation of the system, the authors made the assumption that all distance-learning systems strive to match the amount of learning achieved in a traditional classroom. This assumption allowed the authors to compare the results of their proposed system to the results attained in a traditional classroom without having to compare their systems to a specific "high-end" system. In the end, this choice would restrict the claims the authors could make at the end of the experiment. The authors would be able to claim that learners had been able to achieve a certain percentage of learning in comparison to the traditional classroom at a specific price point, but would not be able to say that the efficiency of their system was a specific percentage better or worse than a high-end system.

Before implementing a solution for their experiment, the authors decided to take a look at the solution commercially available and their capabilities. If the aim of the development portion of the experiment was to achieve an acceptable level of performance in comparison to the other commercially available systems, then the authors would have to know the capabilities of that system.

Distance Learning Solutions

As companies have scrambled to meet the demand for on line content, various methods have emerged. On the higher end, companies have relied on the use of bi-directional interactive video over dedicated ATM lines to achieve broadcast quality bi-directional video. PictureTel's Enterprise product line achieves this level of interactivity and ranges in price from fifty to eighty thousand dollars for a complete solution [9]. Lower-end solutions rely on using the web infrastructure already present at the participant's point of participation to park web content, which learners can access at their convenience.

The classification of distance learning technologies into low-end and high-end is not an objective one. For the purposes of this paper the classification was based on two criteria. First, we needed to consider the use of specialized server components. The authors decided to consider any solution that requires running multiple servers such as Microsoft Information Server in conjunction with Microsoft Media Services as a high-end solution. The rationale was that to deploy a distance learning solution using these tools requires more than just uploading course content to a web site. It requires specialized knowledge in the administration of the server components. Secondly, we decided to consider any solutions that exclude learner's participation based on a minimum level of bandwidth as part of a synchronous solution to also be high-end. By this definition, solutions that use web pages with multi-megabyte video clips and allow the user to download at his leisure would be considered low-end. If the video clip was streamed and required a minimum connection speed, then it would be classified as high-end because learners that were not able to maintain the minimum connection speed would not be able to participate.

At the low-end of the spectrum, the authors found the use of web pages to integrate text, video, audio, PowerPoint presentations, and even white boarding sessions. The common theme in these solutions was the reliance on the user to access the tools provided by the instructor. The instructor would provide links to video clips of his/her lectures, class notes, outside resources, and even to specialized ActiveX components such as embedded NetMeeting ActiveX Objects, which allow the learners to collaborate via text chat or white boarding sessions. Through this mechanism, the instructor gained the capability of providing his students with a method for accessing file archives, remotely accessing databases, newsgroup discussions, syllabi, e-mailing, participating in chat rooms, and engaging white boarding. Due to the asynchronous nature of this approach, feedback would be restricted e-mails, self-instructional FAQ pages, or text based chat sessions. One particular site, Blackboard.com, expanded on these capabilities by allowing the user to conduct real-time IRC style collaborative chat sessions [11].

Higher-end solutions, as we have defined them, rely on the orchestration and integration of dispersant technologies with increased bandwidth to deliver media rich instructional content. The focus is on using technology to deliver high quality video, audio, and instantaneous interactions with the expectations that matching the sensory experience of the real world as closely as possible will facilitate learning.

To deliver the higher quality media elements, these systems must use a higher bandwidth than a standard dial-up 56k connection. Some systems such as Cisco's IP/TV can consume 1.2 megabits/second on a single video stream component. In the institutionalized setting where T1 and DS3 connections are common, bandwidth is not as much of an issue as it is in the residential market. In that realm, ADSL and cable modem are the only alternatives. In some situations, even institutions have problems maintaining the sustained data rates required by these systems. Both PictureTel and Cisco offer solutions capable of transmitting full-screen full-motion video at 30 frames per second but can easily consume up to five megabits per second [8, 9]. To stream two MPEG-I 1.2 megabits/sec video streams, as it would be needed for two-way videoconference, it would require more bandwidth than a single T1 line could provide. In all cases, the uses of specialized server components are necessary to provided functionality beyond what HTML, JavaScript, or VBScript can provide.

The end result of these high-end systems is that learners have the capability to speak to their instructor and fellow students in real-time. If the students have questions, they just have to raise their hand and the instructor can easily address them. It allows allows the instructor to alter his instruction based on the visual and audio feedback he is receiving from the learners.

Experiment

The authors decided to attempt to construct a system for delivering instruction that would provide video quality similar to that of the higher-end solutions while using maintaining the cost of their solution in the neighborhood of the lower-end solution. The expectation was that by providing a higher quality video stream, the learner would achieve a higher level of learning than through the lower-end methods. The net result would be a system that would be more efficient at delivering instruction than many of the current system. Because it would be prohibitive expensive to test the system against all permutation of available systems, the authors went on the assumption that distance learning systems attempt to match the amount of learning that occurs within a traditional classroom. Therefore, if they could show a high level of learning against a traditional classroom, then they had achieved their goal.

A second year Construction Graphics course in Department of Computer Graphics Technology at Purdue University was randomly divided into two equal groups of approximately forty-five students. One group was instructed to attend a regularly scheduled lecture in a traditional auditorium classroom. This would server as the control group. The second group was instructed to receive the instructional materials via the web. To measure the amount of learning attributable to the instruction, both groups were given pre-test and post-tests.

The traditional group reported to class and was instructed to take a paper based pre-pretest. They were given an unlimited amount of time to complete the pre-test. A thirty-five minute lecture was then administered. Finally, they were given a paper-based post-test. The environment of the lecture was identical to a normal lecture, with two exceptions. First, two cameras were housed in the room. These were used to record the material the experimental group would see. The authors considered staging a lecture for just the distance group, but by using the same video material for the two groups, the authors were ensured that they would not be introducing any confounding variables by varying the instruction. A potential problem that the authors did not address was how the presence of the cameras affected the participants getting the instruction live. The second modification was the inclusion of the pre-test and post-test during a regular course lecture.

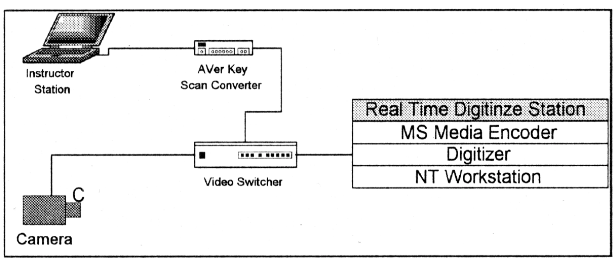
The experimental group was instructed to go to a computer laboratory and follow the instructions on a specific web page. First, they were administered a computer based pre-test that was identical to the one taken by the traditional group. They were then exposed to a video file, which contained the events of the lecture. The video was switched in real-time during the taping session during the traditional group session. One stream contained the video from the instructor and a second stream contained video from the PowerPoint slides presented by the instructor. The file delivered to the experimental group was edited to alternate between these two streams as appropriate for instruction. The moment at which the video file switched from the instructor to the slides was predetermined by the editing and could not be set by the students in the experimental group. The participants of this group were also provided with a mechanism for going through the PowerPoint slides at their leisure though a hyperlink that would bring up the Web

PowerPoint viewer within Internet Explorer. This provided students who were unable to view the stream because of missing video codecs a way to access the instructional materials.

Microsoft Media Encoder was used to compress the video into Microsoft's version of MPEG-4 at a data rate of 768 Kilobits per second and a frame size of 352 x 240 at 29.97 frames per second [10]. This would allow the video to be expanded to full screen during presentation at a quality similar to that achieve with some of the higher-end systems. The video was housed on a media server at Purdue Statewide Technology Kokomo, approximately fifty miles away from the computer laboratory the students would use to receive the file in West Lafayette, Indiana. The rational for using Microsoft Media Encoder was that it is free to owners of Windows systems and that it provides a mechanism for compressing and streaming video at a quality very competitive with that of some of the higher-end proprietary solutions. In combination with Widows Media Server, this system can multicast a stream at a rate of up to 3 Megabits per second to an almost unlimited number of clients (see Figure 1). The Windows Media Server is capable of sending a single stream that all windows media applications tune into and display. This allowed the authors to send a single stream at 768 kbs instead of sending a stream for each student. The decision to stream at a rate of 768 kbs was made because the Kokomo site only had a single T1 line. At this rate the stream would consume half of the bandwidth available to the campus.

At the conclusion of the session, the students were asked to take a computer based post-test.

Figure 1 Windows Media Set-Up



Data

The tables below reflect the performance of the experimental group, which received the Internet based instruction, and the control group that received the traditional instruction. The traditional group was composed of forty-one subjects and the Internet based group forty-five. The authors decided to use the same questions in the post-test along with five more that related to specific components of the original 10 questions in the pre-test. The course was mostly composed of Building Construction Management students in the School of Technology at Purdue University.

Table 1 - Traditional (Control Group) Pre-Test

Quest. #	Right	Wrong
1	38	3
2	29	12
3	31	10
4	22	19
5	25	16
6	18	23
7	20	21
8	19	22
9	40	1
10	41	0

Table 2. - Traditional (Control Group) Post-Test

Quest. #	Right	Wrong
1	29	12
2	24	17
3	33	8
4	36	6
5	16	25
6	22	19
7	38	3
8	37	4
9	39	2
10	39	2
11	24	17
12	26	15
13	27	14
14	34	8
15	40	1

Table 3 - ***Web (Experimental Group) Pre-Test***

Quest. #	Right	Wrong
1	42	3
2	34	11
3	33	12
4	38	7
5	29	16
6	25	20
7	32	13
8	30	15
9	37	8
10	45	0

Table 4 - ***Web (Experimental Group) Post-Test***

Quest. #	Right	Wrong
1	32	13
2	30	15
3	40	5
4	41	3
5	29	16
6	24	21
7	36	9
8	33	12
9	39	6
10	37	8
11	26	19
12	33	12
13	30	15
14	34	11
15	45	0

Discussion

A cursory analysis of the results reveals no significant differences in the performance scores between the experimental and the control group. In all cases, performance increased significantly on the post-examination. This would seem to indicate that both methods were successful at educating the learner. Therefore, we could conclude that the method employed by the authors succeeded at achieving results commonly attributed to high-end distance learning systems, but at a much lower price point.

An interesting finding is the relationship of how the students performed on the pre-test and post-test when looking at individual questions. Looking at the data closely reveals interesting similarities between the two sample groups. You will find similarities in each sample between the numbers of students who answered questions correctly in pre-test, then answered the same question incorrectly in the post-test. This suggest that students might have guessed correctly at the answer in the pre-test; and still not understanding the concepts, answered incorrectly in the post-test. It is also noticed other questions had significant improvements between pre-test and post-test data.

A more detailed examination of the data revealed some variables that could not be discounted when interpreting the data. First, we need to consider that the video for the web group was taped live while the traditional group was receiving their instruction. On the surface, this seemed necessary to assure that both groups received the exact same instruction. An informal interview with the instructor revealed that he purposely accelerated the pace at which he presented information in order to make sure that the video file produced contained "all of the materials for the lesson being covered." He also indicated that he did not provide many places for the audience to ask questions. Interviewing a few of the students at the traditional session reinforced these points. The net result was that by going at such a speedy pace and not providing ample time for questions, the instructor negated the natural tendencies of a traditional class. At the same time, we need to consider that the web group had the option of viewing the video files repeatedly. The web group also had the opportunity to view the instructor's PowerPoint slides directly. The traditional students had to write their own notes while listening to a lecture they could not replay. Thus, we cannot discount the possibility of the method of presentation employed favoring the web group.

A second issue that needs to be considered is how the lack of the codec impacted those students who were unable to view the video. An informal interview revealed that those students felt they were at a disadvantage and tried to compensate by meticulously going over the provided PowerPoint slides. This makes it impossible to differentiate between the performance increase that could be attributed to the video and that attributed to the slides alone. This makes no difference when comparing the distance learning solution to the traditional solution. But, it does pose a problem when we try to consider the efficiency of the system. A system that uses only PowerPoint slides is much easier to maintain, less costly, and ultimately more efficient than one that relies on streamed video.

While this experiment does not account for every possible confounding variable possible, it clearly illustrates that by using the latest technologies it is possible to construct a distance learning solution capable of attaining the same level of media delivery as that obtained by high-end systems which cost many thousand of dollars, but at a much lower cost. Other scholars have suggested that the way to succeed at distance learning is by approximating the same level of interaction we have in a traditional classroom, but in a distance environment. If we accept that to be true, then the significance of the results found in this study suggest that educators can use less expensive tools to reach the same level of performance increase that found in proprietary systems. The net result is higher learning efficiency.

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