Assessment of Student Performance in an Internet-Based Multimedia Classroom

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ABSTRACT

Much research has been devoted to the study of exclusively distance-learning paradigms for teaching various technological subjects, yet many students have not been satisfied with existing distance learning methodologies. This paper addresses a new approach called the cyber classroom, which combines the best practices of distance learning with traditional "brick and mortar" classrooms through technical facilities that allow lectures to be automatically recorded and made available for viewing/download on the world-wide web to all students in the class. The system approach does not force a distinction between in-class and distance learners, and students are allowed to dynamically choose whether they wish to attend class or learn remotely on a class session by class session basis. Past results have shown that the students prefer this dynamic method of delivery over all other class formats. This current paper focuses on the actual student outcomes in terms of grade distribution from courses taught prior to the development of the cyber-classroom and the grade distributions from classes taught in the room by the same faculty where we show a nearly one-half point mean grade improvement, a 36% increase in honors grades, and a 56% reduction in failures.

Index Terms**--** Multimedia communication, Educational technology, Computer science education.

1. INTRODUCTION

Various studies [2][3][4][5][6][7] support the contention that there is traditionally a disparity in the educational experience between in-person and distance-learning (DL) students. These studies suggested that properly applied technological solutions to common DL problems can improve the overall learning environment for these students. These studies collectively provide support for the contention that the best practices include: audio and video delivery of course content coupled with integration of natural handwriting into online slides and the ability to receive real-time feedback during the streaming real-time download of lectures.

In an environment in which large percentages of students are non-traditional and who must commute to school, there are several typical challenges faced:

1. Students may work full-time and they must schedule school around their job.
2. The distance the student lives from campus makes commuting to school costly.
3. The student may have extended periods of work-related travel where he/she cannot come to campus.

In addition to the challenges faced by the commuter students, there are a number of other potentially conflicting challenges. Not all university classes can be offered at times convenient to all students, many students prefer traditional *brick-and-mortar* classroom environments, many faculty members prefer the in-class environment to better match their teaching styles, and yet other faculty members are relatively technology averse. Therefore, a solution was developed that combines the best of interactive distance learning with the traditional classroom experience while requiring minimal training for the faculty and no technical support.

In previous work [1], the authors discussed a *cyber classroom* concept, in which traditional brick-and-mortar learning is combined with distance learning. The cyber classroom allows students to attend courses in-person or watch and participate using streaming Internet video on a day-by-day basis depending on their immediate life issues. It uses an automated capture and recording system that provides a nearly one-button-touch recording of the classroom setting and publishing of the resultant content to the world-wide web. The system supports numerous presentation inputs, including video of the lecture, PowerPoint, over-heads, and white-board inputs, in addition to video and "traditional" slides. Students participate in the class either interactively or off-line using email and discussion boards. The classroom provides the students with not only maximum flexibility but multiple modalities of learning styles.

Logistically, it has improved the distance learning experience for both our students and our instructors; our students have the option of attending class or watching from home/work, and our instructors are able to deliver class without having to substantially adjust their style of delivery in the classroom. These assertions are supported by results presented in our prior work [1], highlighted in , which shows that students dramatically prefer the cyber classroom format over all other class formats. This paper extends these results and examines whether our cyber classroom is having a positive effect on the performance of our students. We demonstrate that overall classroom performance, as observed in the final grades assigned, has improved relative to the performance observed before adoption of the cyber classroom.

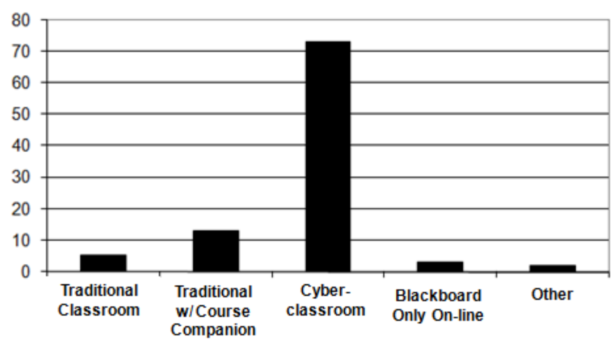

Figure 1: Overall student preference of course format.

2. BACKGROUND IN DISTANCE LEARNING

Many schools have been adopting to Internet-based solutions for their online course offerings. Specifically, Internet-based solutions, such as BlackBoard, WebCT, and eCollege, have been adopted as complete distance learning tools [8][9][10], and their advantages and disadvantages are presented in Table 1. The drawback of distinct material for in-class and online students is particularly crucial for smaller schools where it is often not possible to simultaneously offer in-class and online sections of many courses. This forces students who are uncomfortable with online to wait another semester or risk taking the online course. The authors postulate that this forced distinction between online and in-class learning, i.e. the distinction between brick-and-mortar and Internet learning, may be abstracted away if a suitable multimedia learning environment can be developed.

Table 1: Benefits and Disadvantages of Commercially Available On-line Systems
Benefits:
o Relatively inexpensive to implement o Provides common look-and-feel across university o Provides many commonly required course management tools o Provides interactive chat capabilities to provide student-student interaction
Disadvantages:
o No mechanism for interactions of distance learners during class time o No direct mechanism for capturing classroom discussions/activities o Caters to one specific learning style (reading-based learners, since material is primarily static) o Leads to distinct course material for in-class versus online sections of courses o Often forces students who are uncomfortable with online to wait another semester or risk taking the course (smaller schools can only offer one section per course for many courses) o Requires a significant amount of training on how to develop an online course, which instructors are either not always willing to complete or simply lack the time.

Many researchers have defined candidate factors that must be included in the decision of the appropriate mechanism for interaction for distance learners, with Hart-Davidson and G. Grice specifically identifying the following [5][4]:

- Time: synchronous (real-time) versus asynchronous (delayed)

- Medium: video – send/receive, audio – send receive, chat sessions, and file sharing
- Site: remote/local classroom, in the home, in the workplace, and alone versus with others
- Connection Quality: smoothness of audio & video transmissions

Using these factors, they define the recommended approaches for designing online courses based on the characteristics of the target student body. Recommended approaches are guided by whether the students will participate in groups or alone and whether they will be participating in a real-time or a delayed manner. Since we are interested in reaching individual students in a commuter setting, our students participate in online classes alone. Likewise, since our students typically have work-school timing conflicts, they prefer to participate in our classes in a delayed, asynchronous manner. Since there is a strong interest in capturing the in-class discussions (both verbal and written), our department built a system that was designed to transmit both audio and video to provide the distance learners the feel of being in class. To provide a mechanism to engage the distance learner in these discussions, we adopted a system that allows both student-to-student and student-to-faculty interactions via chat-type sessions using threaded discussions. This system has also been adopted by other researchers such as both Hart-Davidson [5] and Deniz [4].

3. DESCRIPTION OF THE SYSTEM

Using these factors, they define the recommended The general architecture of the cyber classroom is illustrated in Figure 2. It is divided into three subsystems: (i) presentation, (ii) recording, and (iii) distribution. The system is fully automatic and only requires the faculty to activate the system power and press a record switch at the beginning of each class, making it suitable for faculty at most levels of technology comfort. The presentation subsystem provides the faculty with access to significant multi-media resources for providing educational material to all students. It enables the presentation of written materials via a digital whiteboard and a document camera. It also has personal computer (PC) and DVD interfaces to allow the presentation of pre-developed materials, such as PowerPoint presentations, pre-recorded video, and any other electronically stored materials. All of these devices are directed into the central room projector. The faculty implicitly controls the material recorded simply by selecting which material source is displayed on the projection screen with no intervention required by an audio/video technician.

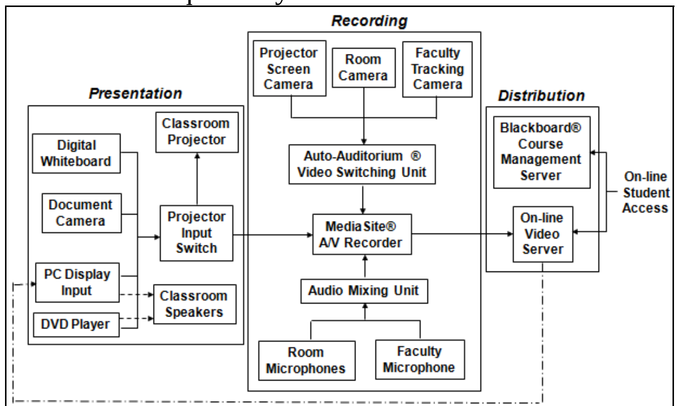

Figure 2: System architecture of the cyber classroom system.

The Recording subsystem captures inputs from a camera focused on the projector screen, a room camera, and a faculty tracking camera, as well as audio inputs that include room microphones and a faculty microphone. The inputs from these three cameras are sent to an AutoAuditorium video mixing unit that automatically mixes the three video sources based on relative change in each camera [11]. The mixed video and audio signals are combined in a MediaSite video recorder [12]. In addition, the selected input from the projector input switch is sent directly to the MediaSite video recorder. This allows either a video-only format or a video plus high resolution projection screen input to be provided to the students based on the faculty's choice of recording style.

The distribution subsystem provides delivery of the course material to the students. There are two key components, a video server and a BlackBoard based internet course companion. All material delivery and interactions for the course occur through either of these mechanisms. As Hart-Davidson and Grise recommend, all of this supplemental material is posted well before each class to ensure all students have access to the material either during the lecture or while viewing it remotely [5]. Student interactions occur via emails to the faculty, as well as through discussion threads or emails via the course companion.

4. IMPACT ON STUDENT PERFORMANANCE

The cyber classroom allows students to attend class in-person or view the lectures online at their discretion and in a fully dynamic manner based on their changing life commitments, rather than being forced to select in-class or online attendance during registration. Many students report that they use the recordings as supplemental lecture material by attending class in-person and reviewing the recorded lectures at a later date. This usage was not originally envisioned by the faculty, but it may be a key factor in explaining the improvements in student outcomes as assessed by final grades that will be discussed next.

The cyber classroom has been operational for approximately 1.5 calendar years, during which over 720 actual classroom recordings have been made. All of the courses were from a Computer Science undergraduate and graduate curriculum. This paper focuses on student performance in a subset of junior- and senior-level courses in which student performance could specifically be compared prior to and after the adoption of this classroom. The courses include: algorithms and data structures, computer architecture, computer networking, software engineering, and theory of computation. The courses involved in the study were taught by three separate tenured or tenure-track faculty members in our department who have been teaching each of the courses for a number of years. The study includes 16 course sections taught prior to the adoption of the cyber classroom, with 448 lectures given to a total of 176 students, and 11 course sections taught in the cyber classroom format with 308 recorded lectures given to a total of 173 students.

Figure 3 presents a graph comparing the grade performance of students taking classes prior to the cyber classroom adoption to those taking classes after its adoption. It shows the number of grades received by the students in each of the sample populations, for every grade ranging from A+ to E (failure), as well as 'W' for withdrawn. There are four important trends to note in Figure 3, (i) increased mean grade, (ii) reduced standard deviation, (iii) increase in honor grades (B+ and above), and (iv) a dramatic reduction in failures. mean grades also improved significantly, as illustrated using the following formula: by assigning grades according to a 9-point scaled as used in our graduate school (A+ = 9, A = 8, A- = 7, …, C = 1, D and below are 0), the mean improved from 3.56 (between C+ and B-) to 4.31 (slightly better than B-), an improvement in the average grade by a factor of nearly half a point. This increase in grade average also correlates well with anecdotal evidence from the student survey open comment questions where many students stated they used the cyber classroom recordings to review difficult material and also to study for exams. The second point was there was an observed 10% reduction in the standard deviation of the grades from 9.7 to 8.7 implying that the consistency of student performance improved, and also possibly indicative of the reduction in the 'double hump' effect that was driven by a relatively high failure rate in these upper-level courses. The third point is that there was a distinct increase in the number of higher performing students (those receiving B+ and above), from 55 to 75 (or a 36% increase), after the introduction of the cyber classroom. The fourth and final important trend is that there was a dramatic reduction in the number of failures in the classes with the number of students failing in these classes being reduced by over 56%, from 32 students to only 14 students.

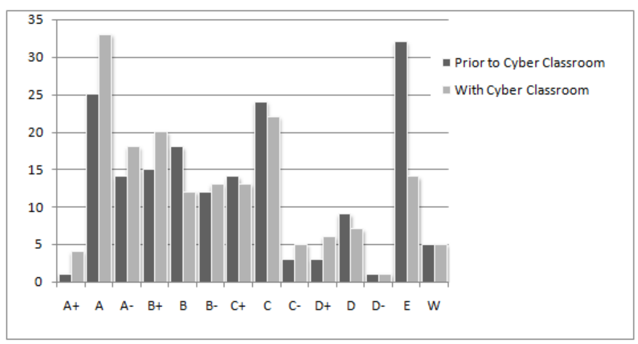

Figure 3: Student grade performance before/after adoption of classroom.

5. SUMMARY AND CONCLUSIONS

The advantages and disadvantages of distance learning are well-studied. It has often been a controversial subject within the educational community. While many universities have been fairly quick to adopt commercially available distance learning products, such as BlackBoard, most educators view the traditional brick-and-mortar classroom experience as superior due to the ease of supporting multiple student learning styles as well as the ability to naturally embrace multiple teaching styles. Likewise, distance learning has received mixed reviews from students, some favoring the approach since it best matches their lifestyles, while others aggressively avoiding distance learning classes. The objective of this research was to ascertain whether a new type of distance learning technology can bridge the gap between the pure traditional and pure online experience.

Past results relating student satisfaction demonstrated that the integrated cyber classroom experience described here was significantly preferred over all other classroom formats. The results presented here now further extend the benefits of the cyber classroom by demonstrating a significant improvement in student outcomes as assessed by final grades with a nearly half grade improvement in mean grades, a 56% drop in failing grades, and a 36% increase in grades B+ and above. The significant drop in failing grades can directly be attributed to the integrated blending of on-line and in-class formats through the cyber classroom, since most failures in our students can be attributed to the students 'vanishing' for extended periods of the semester due to external problems and commitments. The cyber classroom allows these students to remain connected and participating in the class despite their sudden inability to come to class thus validating the concept of integrating online and distance learning for maximum flexibility in student participation. The one-half grade improvement in the mean grade and the reduction in the variance of grades demonstrates there is a clear advantage to all students to be able to review the classroom experiences at a later date to facilitate grasping difficult material and for studying for exams. Future work will be directed at a continuing long-term study of the effects of this classroom to continue to monitor and quantify improvements in student performance through the cyber classroom technology.

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