OVERVIEW OF A DISTRIBUTED-HARD-DRIVE-BASED EDUCATIONAL PLAN

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Abstract

Although empirical research indicates that media selection may not impact learning a great deal, results are inconsistent and sometimes contradictory. We have done recent studies indicating that inconsistent results may be caused by the extent to which educational developers are modifying the genres within which they typically teach – e.g., converting lectures to essays and converting demonstrations to posted instruction sets. Typically, the instructional developers who significantly modify their educational genres do so because digital media (usually designed for dissemination on the Internet, CD-ROM, or DVD) preclude the large format heuristics we accept as necessary in our traditional classes. New technologies, available this year, seem to provide a solution for this problem. In recent studies, we have successfully placed traditional educational genres on very large, external and/or removable hard drives which we combine with Internet technology to overcome the bandwidth problems we faced in the past. Because this involves a unique, step-by-step process of examining educational materials, re-combining them into external drive technlologies, and then developing new distribution methods, we call the process "Distributed Hard Drive Protocol." This paper describes six new, protocols we have developed for educators, trainers, and archivers.

Introduction

Since 1992 we have developed and tested a variety of CD- and Internet-based, multimedia modules and have presented the results in a variety of venues [1-8]. Other researchers have participated in similar studies and have presented similar results [9-17]. With few exceptions empirical research has implied that media selections seem to make little difference in education. On the other hand, in 2001, David Hailey, et al. published, "Distance Education Horror Stories Worthy of Halloween," that seems to imply completely different findings[8]. In this article, the authors argue that they found Internet-based education to be "unpredictable and explosive. A few troublesome online students may stage vitriolic and embarrassing attacks that can sometimes threaten a teacher's career." Based an examination of more than 400 online courses taught at Utah State University between 1995-2001, and written both by teachers and administrators, the article argues that while they can be an effective approach to education, online classes are unlike face-to-face classes *and* they can be dangerous to teachers that attempt to teach them naively.

Although this clear contradiction might seem troublesome for researchers who maintain the "media make no difference" posture, we argue that it points to a different and more important, issue. The problems that arise in the distance education classes we examined come not out of the media but out of the genres the media permit. For example an essay posted on the Internet is not a lecture. Nor is it an acceptable substitute. More subtly, a streaming, "talking head" (e.g., those postage-stamp-sized news broadcasters on the Internet) is not a viable substitute for a comprehensive "chalk talk" (traditional classroom presentation using black- or whiteboards). While the "talking head" and "chalk talk" are both lectures, they are nonetheless different genres with different pedagogical results. Our first claim in this paper is that medium seems not to matter but genre matters a great deal. This claim leads to three additional claims: (2) educators should use sound understanding of how each genre affects learning when substituting one for the other in online instruction, and (3) educators should select instructional media capable of maintaining the integrity of relevant genres.

Finally, in addition to arguing that we should preserve the integrity of the genres we use for teaching, we intend to present a set of newer and simpler educational protocols that permit educators to use the Internet for interactivity while circumventing Internet bandwidth and packet switching problems. These protocols involve placing large-format content on large, hard drives distributed to students, libraries, and educational departments (Distributed Hard Drives – DHDs) and making them accessible in new ways. We are hopeful that with these new Distributed Hard Drive Protocols (DHDP) educators can deliver better education for less and with many fewer complications.

Preliminary Definitions of the Two Important Terms We Use: Genre, Media

Genre

Although genre theorists do not have a universal definition for "genre," Carolyn Miller[18] has advanced an excellent description in "Genre as a Social Action." In this description she posits the argument that genres are both formal and situational. For our purposes and using her description, we present the following as a working definition: "Genre" is a descriptor of the classification of information based on the formal, and social aspects of that information as it is archived or transferred. As is usually the case with definitions designed to be comprehensive, this one makes little sense without more explanation. Briefly, we are trying to say that to identify the genre of a block of information, we must examine its form (structure and physical nature), plus how and why it is being delivered and how and why it is being accessed. Being able to factor these elements can be extremely complex and powerful, making it possible to contrast between genres as similar as rap and hip-hop music. It also makes it possible to examine and classify individual genres and arrange them into related groups (classes). For example chalk talk, PowerPoint presentation, demonstration, talking head, parental scolding, and sermons are all genres and may all be categorized under the greater classification, "lecture."

Structure and Physical Nature of Genres

By "physical nature" we mean the voice and structure of the information. For example, a manual is a written collection of informative segments, designed for quick access to solutions, and will include no self-testing components. A textbook is a written collection of informative segments that typically includes self-testing components (e.g., homework, quizzes) and is usually segmented so that information from a subsequent segment builds from information in previous segments. The voice of the guide will typically be concise, while the textbook will be more prosaic and may have narratives.

Media and Genre

One of the reasons, readers will often fail to note the difference between books such textbooks, guides, and manuals is because they are usually all the same medium -- book. But we all know that these books can all be effectively digitized. While media play some roles in describing genres, their contributions are relatively unimportant. If the genre called "textbook," is digitized, its effect on a class is minimal. If the textbook in a Thermo I course, however, were converted into a novel, its effect on the course would be catastrophic. Far more important from the point of view of understanding genres are the genres' purposes and how are they used?

Nature of a Genre's Purpose

By purpose we mean, for what reason was the work created? Television news and documentaries are designed to inform and entertain; manuals are developed to provide immediate access to technical support, and textbooks are developed to support courses.

Nature of a Genre's Use

A third approach to identifying a genre is to examine how the work is accessed. Textbook users are usually led by teachers who help them combine the step-by-step information into a greater and more conceptual understanding of a global topic (e.g., heat transfer, quantum physics, history). Manual users will usually look a topic up in the index, then read and immediately apply the information they find in the relevant passages. In short, a textbook can be contrasted with a manual in part by its purpose (educate broad concepts), its structure (usually containing homework problems, solutions and similar educational tools designed to support a class), and the manner in which it is designed to be used (students lead by teachers through the materials).

At the risk of pointing out the obvious, what we said about removing the textbook from a course or replacing it with a novel also applies to lectures in courses that require them. If you remove the lecture from a thermodynamics course, the results could be catastrophic. And if you replace the lecture with a different genre (e.g., a posted essay, or PowerPoint slides and sound files) the results may be unpredictable. In short, we claim that changing genres to convenience our media selection is problematical; selecting the appropriate media to support our genre choices is critical.

New Drives and New Courses to Put on Them

During the summer of 2001, Iomega Corporation introduced the 20GB "Peerless," its new removable hard drive. The same summer, Maxtor and Buslink introduced even larger, external hard drives. Other companies are developing similar products. The drives operate at the same speeds as internal hard drives, but they are external and designed so that the computer that they are attached to immediately sees them as newly installed hard drives. They come with USB I, USB II, or IEEE-1394 connectivity. Perhaps more important, these drives represent only the very beginning of this technology. Ranging from wallet to book size and from 10 to180 gigabytes, these drives are little more than "trilobites" when compared to their future replacements. Even so, they are already cost effective, and provide more than sufficient speed and size to contain all of the content for large and complicated classes. A student anywhere can connect the drive through a USB or Firewire port and can take the class anywhere, anytime. Ironically, these DHDs require a step back in delivery technology: that the drives be mailed or similarly delivered. On the other hand, we calculated how long it would take to deliver the content for one of our new classes over the Internet to a student with a 58.8Kbs modem (more than 250 days if there were no interruptions and if the modem could actually run at 58.8); then we compared that to delivery by traditional mail. We found that compared to the Internet, we could much more quickly, dependably, and cost-effectively deliver classes by mail, and still use the Internet for interactive communications.

Developing Courses for DHD Delivery

In anticipation of the new drives, in the autumn of 2000 we began developing new instruction and adapting old materials to utilize DHD size and speed. Over the past year we have moved high-resolution video lectures and demonstrations, 3-D animation, and similarly large media onto these drives and have begun testing our results. Generally, we have discovered that conversion to digital is significantly simpler and more flexible when converting for use on DHDs than when converted to HTML. For example, during the 1997 through 1999 academic years, we developed and tested a thermodynamics course for distribution over the Internet[5]. In the production of the course, we developed and tested applications using CGI, Java, JavaScript, ASP/SQL, and DHTML tools. After a variety of different experiments, we concluded that the tools were consistently difficult to use (often requiring that we hire specialists) and their results undependable. In the end, we were only able to produce and distribute lectures as still images, 2-D (Flash) animations, and sound files, but we could never know if these files would work on remote sites, and when they worked, we never knew what they were going to look like. We had somewhat better results with using Java for interactive testing, but as with the tools above, we found that it only worked on properly configured systems – not common among student computers.

In contrast, during the summer of 2001 we created a new thermodynamics course containing 45 hours of "chalk talk" (at 640X480 resolution) broken into segments of five- to ten-minutes, and supported by 2- and 3-D animations and high-resolution illustrations. It also contains more than 24-hours of sound files with accompanying charts, illustrations, and content from the textbook (permission granted by the publisher). Finally, it contains a variety of interactive quizzes designed to permit students to test their own progress. The complete project is slightly more than 67 GB. In developing this course, we made every effort to include the genres available in the traditional course. In some cases, we improved on the course by upgrading genres (e. g, animations to replace static illustrations) or adding new genres (e.g., interactive workbooks and self-test quizzes) that had proven their value in previous studies. The course is presently in use in Utah and in Texas. In Utah the course is being used for distance education. In Texas the same material is being used to enhance a traditional course for moderate learners and at-risk students. As an additional note, in a different but similar course (introduction to manufacturing engineering), we are adding 48 hours of videotaped demonstrations and visits to remote sites.

Distance Education vs. Traditional Classes

We should point out that although these media are effective for distance education, they go well beyond that goal. Of the uses we have discovered for DHDs, the most common involve improving traditional education. We have established six different structures within which our media may be distributed and used by educators and students.

Distribution Models – An Introduction

Below we present six distribution models for DHD-based material with examples of content that might be presented with each model. For example, one could develop a DHD-based review course to help students prepare for the Fundamentals of Engineering Examination (FEE). There are a number of ways the review material could be distributed. A dedicated hard drive could be attached to an instructor's computer, networked into a LAN and distributed to students within the institute's computer lab system. Or the material could reside on a hard drive that is checked out from a local public library. For sake of example, we include the FEE review example in Distribution Model 2 – DHD-based Content Resides on Shelves in Libraries for Student Access. We want to emphasize the point that the examples are not limited to a single distribution model.

Distribution Model 1 – Attached to the Teacher's Computer and Distributed to Labs to Enhance Traditional Classes

DHD-based material is attached by Firewire to teacher's computer, networked into the LAN and distributed to students within the institute's computer lab system. In some cases, it can be networked directly into dorm rooms. For access, students simply map to the teacher's drive. Student file management software sees the teacher's drive as if it were on the student computer. Any software installed on the teacher's drive runs as if it were loaded in the student computers.

There are three significant advantages: (1) retention of at risk students, (2) classes that should have labs but do not can be modified to include integrated lab time (3) in some cases, advanced lecture classes can be converted into theory/discussion/problem solving courses.

Retaining Students at Risk

Students who might well have viable futures as engineers often drop, fail, or are driven from their studies because they have unique learning skill, or disabilities, or have inadequate access to critical courses (e.g., conflicting work or class schedules). These students often need nothing more than a different forum or more opportunities to examine the material. Teachers can make high-resolution versions of their lectures available to the students, combined with video of them (or students) working additional problems, they can provide real world demonstrations or high-resolution animations of theoretical problems to improve students' physical understanding, they can even provide videos made available by manufacturers or fair use doctrine.

Between 1998 and 2001, using CD-ROM and internal hard drive technologies, we tested this option in several thermodynamics classes in Utah and later in Texas. Student grades for those who accessed the additional material typically improved by about one grade point.[5]

In a variation to the above theme, a UT Tyler student was forced to make a difficult decision. Because of work/class conflict, he was left with the dilemma of quitting his job or missing a critical course, putting him a year behind in his studies. As a part of our research, we agreed to capture and digitize the faculty lectures for this student. We capture the lectures, break them five-to-ten-minute segments, and make the appropriate days available on a DHD attached to a teacher's computer as described above. The lectures are password protected, and only this student is permitted to see them. The student is able to continue his studies, but as an aside, the other students in the class have requested that the *all* of lectures be made available to them in time for the final exam.

Improving Courses by Converting Lecture Time to Lab Time

Since 1994 David Hailey's HTML class has been a balancing act, forcing him to sacrifice valuable workshop time for lectures designed to bring students up to speed in theory, history, and technology. Such a course demands that it be taught in a lecture/lab environment. Since English departments typically do not have labs, Hailey is forced to sacrifice either lecture or lab time to be able to teach the class in its allotted 50 minutes. His early solution was to place lectures on line as essays and images. The students universally found this solution to be unacceptable. Our solution has been to digitize the lectures and (additional demonstrations) in high-resolution video and make them available online. Face-to-face time is devoted almost entirely to workshopping. Students may attend the lectures and demonstrations at their convenience and in the order they find most suitable (e.g., one student might find JavaScripting an important early skill for his or her project while another might choose to learn about creating frames).

Improving Classes by Increasing their Rigor

The teacher of a graduate level orbital mechanics class at Utah State University felt that too much of his class time was devoted to lecturing and not enough was devoted to advanced problem solving. During the fall of 2001, his entire course was videotaped and digitized. He also developed a set of supporting lecture notes. In his future classes, students will be required to view the lectures prior to attending class. During the face-to-face portion of his class, students will examine, discuss and solve advanced problems that they would otherwise have no opportunity to see.

Distribution Model 2: DHD-based Content Resides on Shelves in Libraries for Student Access

In this model students use the materials in *situ* or check them out and take them home much as they do books. The model solves several serious university problems: (1) Students can take required courses independently if their sequence is disrupted (2) Students repeating courses can retake them at an accelerated rate without increasing pressure on the teacher or department, (3) Students preparing for professional exams can review critical classes (4) as in the first model, students with disabilities and at risk students can work independently to improve their understanding of content of traditional classes in progress.

Surviving a Disrupted Schedule

Engineering programs often have rigid schedules. If a student misses a calculus class, he or she cannot take a number of subsequent courses (e.g., Thermodynamics I). Missing Thermo I can put a student schedule back for a full year. This is a common bottleneck that proves difficult for the student and costly for the institution. With the teacher's help, that student could take Thermo I or other similarly required courses as a digitally based independent study courses.

We have tested a successful variation on this theme in Utah. The state legislators mandated a change from a quarter-based to a semester-based system. The two state-funded, primary providers of engineering degrees had two different philosophies concerning the number of semester credit hours associated with the first course in thermodynamics. Since the thermodynamics course is sophomore level, it is also available through many community college programs within Utah. The lack of consistency between the two four-year engineering programs left the community colleges in a quandary – do they provide the two-hour course or the three-hour course? To meet USU requirements, students take two hours at their community college and the third hour digitally at USU.

The scenario of disrupted schedules and the one that follows could as easily be applied to Distribution Model 1, but students who find their schedules out of sync pose a significant drain on their teachers and department. It is perhaps better if the library and continuing education programs handle instruction for students who find themselves in this position.

Surviving a Failed Class

Students often fail classes because they suffer poor study habits or use their time badly. But students also often fail because conflicting demands overwhelm them or because at a critical point, they may have missed a key concept and were unable to grasp subsequent concepts. Although this approach may not be effective for students who are still immature, many students who are forced to drop a class before completing it, request an incomplete, or who fail it, often do so at no fault of their own and already know most of the material. They may not need to subject themselves and a teacher to yet another sixteen weeks. Nor should they have to wait a year for another opportunity to take a critical course. As an option, these students could independently retake an accelerated version of the course, completing it in weeks rather than months. Extending this idea only slightly, if a worthy student were on the verge of failing a class, or requesting an incomplete, an engineering program move the student into a digitally equivalent class as an efficient alternative. The student could review the materials he or she had already seen and complete the class for a grade with little or no loss of time.

Preparing for Professional Exams

Students and Alumni from engineering programs often need to prepare for professional examinations (e.g., Fundamentals of Engineering or Principles and Practices of Engineering Exams). These students would find the ability to review key teachers' lectures valuable. Our DHD protocol is too new for libraries to be carrying these disks, but we have tested this concept with CD-ROM instruction in the past with moderate success.

Distribution Model 3 – DHD -Based Instruction Centers Established at Remote Campus Sites

Although they are not all active, the University of Texas educational systems boasts of more than 200 campuses. Many of these campuses are video reception centers where students report for televised classes. Others of them contain classrooms where teachers teach traditional classes. But because televised and face-to-face courses are costly, especially for small student numbers (both fiscally and in terms of human resources), many of these sites remain unused (e.g., of UT Tyler's eight remote campuses only three are in use).

By creating a DHD library in their remote campuses, institutions can reduce or eliminate the cost of traditional televised courses. Such a site could be set up in a corner in a small-town library. Remote students, especially students with no computer hardware or with limited access to the Internet can study at these remote sites – using library hardware and software for real-time access to teachers and other support personnel.

These libraries of drives may also be set up in high schools. High school students who wish to concurrently enroll in university but have no qualified teachers in their schools then have access can use the libraries in a similar fashion. On the other hand, even high school classes may be housed on the drives. Rural states can use them to supply required instruction to students who otherwise have no access to it because the states cannot find teachers (e.g., in Wyoming, a language is required for HS graduation but many rural schools have no language teachers) or because they cannot afford the classes (e.g., qualified math/science teachers).
Expelled, suspended, imprisoned students can be deprived of access to the general student population but still continue receiving their education.

Students with disabilities can attend many of their classes in this environment, giving greater access to one-on-one help.

Although no remote libraries similar to this exist, USU is capturing classes specifically for the purpose of creating libraries at their remote sites, and they play to begin development of concurrent classes for high school sites. Perhaps more interesting is their plan to export these classes to India and China. In these sites, the teachers are under-qualified to teach university subject matter, but with the instruction being exported on DHD, the teachers *in situ* can act as tutors, helping the students with the material without being teacher of record. The first classes planned for this project are chemistry, and business.

Distribution Model 4 – Educational Libraries for Training in Industry

Although corporate training hardly compares to the complications of education, corporate training libraries give us an opportunity to discuss some of the most chronic problems with the Internet – hackers, crackers, viruses, and spammers. We pull works and Trojan horses out of our computers regularly. Any computer directly connected to the Internet for any period of time or browsing the Internet (even) intermittently is in jeopardy. In the case of W32/Nimbda, one need only open an infected web site to become infected. Training materials often contain some of a corporation's most proprietary information. Making it available over the Internet (or even over the Intranet) makes it available to hackers, crackers, worms and Trojan horses. Similar problems are increasingly growing in universities. As network technicians build increasingly impenetrable firewalls, online courses become increasingly difficult to teach. In the case of DHD libraries, firewall and Internet are not problems. Sensitive materials are more effectively controlled– drives are attached to dedicated computers for training, and are locked away when not in use.

Distribution Model 5 – Libraries of Drives for Preserving Processes and Skills in Corporate and Research Institute Environments

In an AIAA banquet in 1999, a vice-president for research at Space Dynamics Laboratory lamented that if we had to build a new Atlas rocket today, we would have to start over. "We have all of our drawings," he said, "but nobody actually knows how to do anything." The problem he was pointing out was that while we are maintaining the information about how we do things, we are letting the knowledge of how to use that information evaporate. This problem touches on the subject matter a growing field of professionals called knowledge managers. An important subset of knowledge management is process preservation. Process preservation involves institutions capturing and archiving critical and unique skills for access by future employees (e.g., the last man in the US that knows how to rig a nuclear weapon's parachute – about 80 hours of complicated procedures – retires in three or four years). Institutions can capture processes and archive them for future proof of originality and/or for historical documentation.

Ironically, it was constructing approaches to process preservation lead us to developing the DHD protocol. We were searching for an approach to controlling the massive amounts of data we created and struck upon the idea of creating libraries made up of pigtailed hard drives. Once we had the protocol designed for process preservation, evolving it from an archival to an educational tool was a small and natural step.

Although process preservation is a valuable tool for preserving endangered technological skills, it proves to be as valuable for preserving other endangered skills (anything from installing a windmill driven water pump to distilling illegal corn liquor).

Distribution Model 6 – Mail Disks to Remote Students for Distance Education

Because so much attention is paid to distance education, the other advantages of the DHD protocols tend to fall away in discussions of educational opportunities. As a consequence, we leave discussion of distance education to last and say the least about it. Because the software we use can open any Windows-based program, we can access the Internet, but need use it only for low bandwidth communication (e.g., email, threaded discussion, submitting test scores). It goes without saying that when any college student can work at home doing studies "anytime, anywhere," education will become significantly more democratic. Less obvious are the values of DHD protocols to K-12 home study students. Parents are usually not teachers. They can use all of the tools they can get. Providing them with a year's worth of education built on content provided by qualified educators, and installed on a single disk raises the quality of education among the home schooled.

Conclusion

Although the Distributed Hard Drives protocols were not originally designed for education, they are becoming an important educational tool. It would take 300 CD-disks, 90 DVD-disks, or 48 videotapes to replace a single DHD drive (although these disks and tapes are unable to hold the content we can place on DHD). More important, perhaps, is the interactivity of the DHD drive. Because we can save on them, students can take interactive tests and save them to the drive.

While the Internet remains too slow for high resolution content, DHDs seem to be the best option. Actually, they may remain the best option once the Internet is fast. If the Internet were fast enough to carry content streaming at 100MB/S, students anywhere in the country could simply network to the teacher's computer and map to the drive, making it their own. Students in New York, mapped to a drive in Tyler, Texas, would see it as if it were on their computer. They would simply double-click on the class and see it without having to resort to Internet protocols. But for now, the Internet remains too slow for demanding content and the dangers from using it grow with every new virus. Given those conditions DHD seems a pretty good option.

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