Information Technology and the Classroom of the Future

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Abstract

Universities are usually successful in creating, gathering, and imparting knowledge. They are less successful in applying that knowledge to instructing. Academic researchers recognize the value-added of technology to communication, efficiency, and decision making, but the whiteboard and paper remain the primary teaching technologies in most classroom. There have been efforts in the academic community to move from a paper-based classroom to a paperless classroom. Unfortunately, these efforts have usually been isolated and generally have not tailored technology to support varied student learning styles. This paper presents a paperless classroom implementation that uses technology to support the model of learning appropriate to a particular learning situation. The focus is not on the technology but how the technology enhances learning.

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Goal

The Department of Electrical Engineering and Computer Science of the United States Military Academy (USMA) is in the sixth year of an on-going project to use technology to enhance learning. The goal is to use information and educational technology to make the transition from a lecture-based, paper-centered learning environment to a discussion-based, paperless one. Lectures and texts are linear in nature, while learning has long been recognized as a non-linear sequence of events. By reforming and reorganizing the way learning material is presented, the paperless classroom enables students to be more efficient in their learning. Applying the paperless classroom concept facilities an active learning environment that uses distributed resources to contribute current information to the student.

The current learning environment is for the most part instructor driven using in class resources. Students attend lectures where topics are developed and discussed and then depart the classroom to hopefully practice or review concepts through readings and homework. In the cases where there is audio or video employed to demonstrate a concept, there is usually little linkage between the mediums. The paperless classroom desires to change to multimedia and hypermedia, linking media and concepts to cater more effectively to students' learning styles and academic desires.

Background

Problem

Despite the proliferation of computer networks and information technology into the classroom, instructors and students still use paper as the primary means of assigning and submitting graded requirements.

Solution

With computer networks, such as local area networks (LAN) or the World Wide Web (WWW), instructors assign, assess, return, and discuss student projects without ever using a piece of paper. This not only saves the cost of paper but also gives the students the ability to display a broader range of information in multiple media. This effort is primarily a pedagogical step towards identifying and implementing student created multimedia in a current technical course.

Previous Work

There is a wealth of research on the positive effects of technology in the classroom (Leidner, 1995). Studies on the introduction of video clips into classroom instruction show that video clips are motivational for students. It has been shown that instructor consoles contribute to both perceived and actual information structure. Classrooms with both instructor workstations and videodisks improve student attitudes about the instructor and the course. Several institutions have reported positive results from the use of electronic mail (email). Overall, the body of literature convincingly illustrates that new technology positively influences student attitudes toward the quality of the instructor and course organization. Several institutions besides the USMA have attempted to institute paperless classroom concepts (Brown, 1994) (Lane, 1995) (Shneiderman, Alvi, Norman, & Borkowski, 1995). None of these efforts have been as broad or as enduring as the efforts at the USMA.

The evolution of a paperless classroom began over six years ago in CS383, Computer Systems. Previously, assignments were handed out in printed form. Lectures were delivered using overhead slides, and students read and annotated printed text book. In 1990, the Academy purchased large screen monitors for all computer classrooms, enabling instructors to deliver material through presentation graphics. At the same time, the Academy network was established, allowing students after-hours access to the instructors' slide shows material. Instructors embedded multiple media items into the slide shows to accentuate or expand on certain concepts. The course was well on its way to becoming multimedia in the classroom, but was still tied to a text course resource.

When the Academy network reached the student rooms, the course began to make serious inroads in the pursuit of the paperless classroom. Students were emailed assignments and given access to shared directories on classroom servers, making it easier for students to ask specific questions or submit class assignments. Multi-user dimensions (MUD) were created and used for student interaction. Other interactively forums were list servers and electronic bulletin boards. They are all used with varying success.

In 1994, course media elements and slide shows were incorporated into a system of web pages that allowed students a nonlinear access the course material. A learning style assessment was added to help students approach the massive amount of material contained in the WWW course resource. A hypertext reading file gave students a new way of pursuing a topic through the reading assignments (Carver & Howard, 1995). For last two years, efforts have been dedicated to expanding the media coverage throughout the lesson material. Throughout these technological innovations, the overriding focus was enhancing the learning environment for the students. Technology that distracted from or did not add to this focus was discarded.

Requirements Planning

Before beginning the odyssey of purchasing and implementing vast amounts of information technology, it is useful to articulate actual requirements. Based on experiences at USMA, the following questions can help ensure that all participants of the budget and planning process are clear on the intent and execution of the transition plan.

Where Are We Teaching?

In this step, instructors should focus on the physical locations of the student and the instructor. If the instruction is delivered in the classroom, one should focus on information presentation. If the student uses the course resource outside of class or in a distance learning situation, connectivity and supporting referential material are important. If using the resource as an integrated tutorial or help system in the work place, structuring the information to answer specific questions is the dominant design theme.

What Are We Going To Teach?

Multimedia is not the goal. The information technology integration process must focus on using multimedia or hypermedia as the means to the end. The goal should always be making learning more efficient. By considering how applicable particular technology is to the target subject, an instructor can assess and articulate where and how technology will affect the lesson. Experience shows that at the beginning of the transformation lesson content will be the same as it was in the older style class. Later, instructors discover they can cover more material in less time because of the power of the multimedia and hypermedia presentation.

Who Are We Going To Teach?

Just as text books are selected so that they are at a meaningful and realistic level for their students, technology used in a paperless classroom should not overwhelm the course material nor scare the students away. Before purchasing any technology, instructors should survey their courses to determine the degree of computer literacy and the overall level of comfort with technology. Experience shows that younger students seem to adapt easily to on-line systems, while older students have difficulty reading large amounts of text from a computer screen.

How Are We Teaching?

Technology should allow lecture based courses to migrate easily into discussion based ones. The key is to create active learning environments. Instructors should consider how they have organized their courses and then find ways to implement new tools. For example, large lecture courses could benefit from having notes, slide shows, or recorded lectures placed on the campus network for student reference.

Learning Environment Tasks

Deliver Instructional Material

Perhaps because professors, instructors, and lecturers perform the task of delivering instructional material on an almost daily basis, this area has seen most of the advances in recent years. Starting with notes written on a chalk board, instructors have progressed to view-graphs and presentation graphics slide shows.

The next step is the use of multimedia to enhance the information content of the presentation. This can be done in several ways. The first is to use several separate media sources and have the instructor switch the presentation between them. For example, he might show a slide show, then switch to a video cassette by turning off the projector and turning on the VCR and TV. This solution has the elegance of simplicity but is hindered by the fact that not all faculty are comfortable with the technology involved in operating and maintaining all the different media devices. A more advanced technique would be to embed the multimedia objects into the slide show and have the instructor select them when they are appropriate to the presentation. The use of embedded graphics has been implemented using Hypertext Markup Language (HTML) and the WWW. Using web pages that link to multimedia files, the instructors use the web browser to select and play the various media files. So far, maintenance has not been an issue due to the wide variety of media formats available through most web browsers.

Another benefit to delivering instructional material electronically is that students can tailor the way they receive the information by their learning style (Carver, Howard, & Levelle, 1996). In CS383, students take a learning style assessment that adapts the lesson interface through the material based on their individual learning style. Used for three semesters now, this assessment tool is implemented using the Felder Learning Model. While this has been successful in a robust multimedia course such as CS383, further work is being carried on to validate the benefits of an adaptable interface to an on-line course reference.

The future of delivering instructional material lies in reaching students outside the traditional classroom environment. This is not only crucial to the student living in a remote area (Farinetti & Malnati, 1996) but is also important to schools with limited enrollment in some courses (McShane & Shaw, 1996) One way to accomplish this is to record video or audio tapes of classroom lectures and mail them directly to students or place them on a web site or networked computer. While this does enable the instructor to deliver material, experience (Hubbard, 1996) has shown that students quickly become bored with the 'talking heads' and are frustrated by their inability to ask questions.

Delivering instructional material can also be achieved with video teleconferencing (VTC) systems. While the cost of these systems range from hundreds to thousands of dollars, their implementation is the same. One instructor sends video and audio signals to students at another location. The students can interact with the instructor by using the system on their end of the conversation. VTC has been used primarily for guest lecturers.

Interact with Students

Once the basic instructional material has been presented to the students, they will often respond with questions or comments that help them gain a better understanding of the material. Traditionally this has been done in lecture classrooms, through office hours, and laboratory sections. The common thread to all three methods is giving the student contact with an instructor as well as instigating conversation among the students as a class. In large courses or situations when the student cannot conveniently travel to the instructor's location, this is typically the first area of education to suffer.

One method for generating student interaction is to use electronic mail (Email) to pose queries, answer questions, and pass along assignments and assistance. A more open forum can also be generated by a mailing list, such as a USENET news forum, list service, or bulletin board system. In these applications, one student's question is passed to all users that are subscribed to the list, allowing many people to comment and keep up with a discussion. Another method that uses computer connectivity to foster interaction is the use of Multi-user Dimensions (MUDs) to enable students to interact with instructors,. At both Georgia Institute of Technology and the USMA, faculty members hold virtual office hours by logging in to the MUD at specified times. Students can pose questions on certain topics in theme rooms, where the question is available to anyone entering the room (Dieberger, 1996)

One of the more innovative means of interacting between students is with a game. The CS383 course uses the action-adventure game DOOM to pose multiple choice review questions to the students (Carver & Gregory, 1996). The goal is to place the students in a familiar environment (a computer game) and then encourage studying through a competitive application (answer the question correctly or your game character dies.) This has been extremely successful and, with a free editor available through the WWW, been maintained to keep pace with the course.

Assign, Receive, & Evaluate Assignments

To increase comprehension of the material, most courses assign projects and paper that force students to demonstrate an understanding of certain concepts. Assignments are given out in CS383 through links on web pages, files on networked drives, and email to students. They search library resources using automated databases, browse the WWW using search engines, and request material from information services like ERIC and Lexis. These are all available to most instructors, but experience has shown that students must be

encouraged to use them. Project requirements to include a multimedia component or hypertext link to outside sources are the first step in showing the student that information is available through sources other than the text book (Adams, 1996)

When the project is due in a paper-based classroom, students print out their paper or project and hand a folder to the instructor. This is not only inefficient and costly but it also denies anyone else the benefit of student research. One simple method of electronic student submission is to create a shared directory on a networked computer and require students to place their submissions there. The instructor can access them at anytime and the projects are available for later use. Care must be taken however to prevent the spread of computer viruses and electronic copying between students. Passwords, permissions, and logs have been useful but not totally effective.

The most elegant method for receiving and evaluating assignments is to have students create web pages and submit their projects as HTML files. This has been done successfully at Brown University (Landow, 1996) and USMA. Not only does it allow student research to be available, it is also a vehicle to expanding projects beyond linear text. Students are able to include graphic, video, and audio components in their projects that were not previously available. The drawback is that electronic submission requires projects to be graded on-line. Qualitative evidence in CS383 has shown that it is no more difficult than reading printed papers.

Assess Understanding and Assimilation

Finally, every course has an evaluation or assessment component. As with the other categories of classroom tasks today, this is mostly done through printed examinations and possibly scanned answer forms. This method has several widely recognized drawbacks:

1. Tests are costly to create in terms of instructor time. Usually, multiple editions of a test must be created to allow fairness between separate sections of a course.
2. Written examinations are costly in terms of time spent evaluating the student responses. Although electronic grading is useful, its restriction of multiple choice tests is too confining for most instructors.
3. Consistency of evaluations can vary because of the time pressures placed on graders. An answer that earned a B at dinner time might earn an F at 3:00 AM!

Automated testing can alleviate these issues. Quizzes can be given through scripts and test programs (Carver, Ressler, and Biehler. 1995) or games (Carver & Gregory, 1996) The advantage to these methods is that a computer can create an almost endless number of different multiple choice and short answer tests with little effort and grade them all consistently. In the case of CS383, the Student Response System can give tests that adapt to the user's demonstrated level of knowledge (Carver & Ring, 1996). The drawback to these methods is one of student validation. Passwords and user names are not stringent enough to prevent students from getting other people to take tests for them. There is also the question of time constraints. Both of these issues are addressed by having the student take the exam in a computer lab at a specified time. In this way, a proctor can verify the student's identity and ensure that the test is completed in a set amount of time.

The Value Added

Whenever educators and technologists begin discussing ways to introduce technology into a classroom environment, the question of value added or return on time invested immediately is surfaced. While it has been shown that students enjoy and are challenged by learning in a paperless classroom, CS383 has also shown that instructors can teach more efficiently. Preliminary or reference information typified by objectives on the lower end of Bloom's Taxonomy can be delivered outside class through electronic means.

This frees the instructor's time to enable higher level concepts to be discussed and exercised during limited lecture or interaction time (Howard & Lane, 1996).

Another, perhaps more tangible, benefit is that studies have shown that students who learned via on-line multimedia retain the information as long as or longer than with only text (Howard & Carver, 1997). Information retrieval is also more efficient, if certain structural methodologies are applied when creating the electronic course material (Adams & Carver, 1997).

Challenges

Each step along the path to a paperless classroom has requirements for integration and maintenance issues that must be resolved in order for the technology to continue to be beneficial. At a minimum, instructors must have the knowledge to place material on networked computers or create multimedia resources for their courses. Following this, of course, is the requirement for students to be able to access the material from their dorm rooms, classrooms, or study areas. This investment into connectivity and network infrastructure is not trivial in the short run, but it shows substantial returns in the long term.

Initial decisions to implement a certain piece of equipment or technology must be made after consideration for both integration with current equipment and expansion in the future. Most institutions have adopted an open systems approach rather than tying themselves to a particular operating system or platform. Normally, their funding does not allow for replacement of equipment within the projected eighteen month obsolescence cycle.

Funding is the most contentious of all the issues raised in this paper. It is undeniably difficult to find funds to initially purchase equipment or software. Additionally, one must budget for proper staffing to ensure maintenance must be budgeted. There needs to be a sustained flow of funds. Another budget planning item is upgrading and eventually replacing equipment. Depending on the technology, this period varies between one and five years.

Conclusion

There are varieties of opportunities for using technology to implement the paperless classroom. Technology is the means to increasing learning efficiency. One can use technology to better display information, increase access to information, improve information sharing, and organize better class presentations. Technology is not a panacea for educational problems, but by combining technology with applicable learning models, the overall quality of education is enhanced. Students raised in an age of technology demand student centered and led learning. Educators must discover and develop how to implement new technologies into the learning environments and focus efforts on facilitating learning - not implementing "multimedia toys."

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