Web-Based Differential Equations: Interactive Learning with the 80/20 Model

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Undergraduate education at Rensselaer Polytechnic Institute has been transformed by the campus-wide use of interactive learning and studio teaching. Rensselaer's 80/20 Model for interactive distance learning is a natural extension of its on-campus educational environment and will form the foundation for the future development of professional and distance education at the Institute. This paper provides an introduction to the evolution of the 80/20 Model, including a description of the techniques, technologies and design strategies involved in developing the synchronous and asynchronous components of an 80/20 course. In particular, the paper focuses on an online Differential Equations course developed and delivered in the 80/20 format.

Introduction

The issue of interaction in distance learning has received considerable attention (Moore, M., 1989; McNeil and Nelson, 1991; McKinnon et al., 1995; Wagner, E., 1997). Starting in the late 1970s and early 1980s, various researchers began to add asynchronous computer communications and synchronous interaction via two-way cable television and audiographics to traditional distance learning technologies. These studies indicated that interaction greatly enhanced education at a distance with improved attitudes, earlier completion of coursework, better performance on tests, and greater retention all cited as positive benefits (Baath, 1982; Kwiatek, 1982; Barker, 1986; Lister, 1988). Unfortunately, these early technologies were often extremely expensive and technically challenging to implement. More recently, numerous studies have indicated that interaction (both synchronous and asynchronous) amongst students and instructor not only enhances learning (McNeill and Nelson, 1991; Waggoner, 1992; Harasim, 1993), but is often the most important variable affecting student satisfaction in distance education courses (Fulford and Zhang, 1993; Kearsly, 1995; Kirby, 1999). The advent of Web-based distance learning and the proliferation of tools that support both asynchronous and synchronous learning over the Web, have ignited yet further interest in the effects of interaction at a distance (Kahn, B., 1997; Lister et al, 1999).

At Rensselaer Polytechnic Institute, the development of interactive distance learning courses has been a natural extension of our on-campus Studio teaching environment which has transformed undergraduate education through campus-wide implementation of interactive learning (Wilson, 1994; Wilson, 1997; Glinkowski, Hylan and Lister, 1997). After several years of development, Rensselaer has recently adopted a distance learning model that attempts to create

virtual studio courses at a distance and capture the benefits of hands-on learning for our off-campus students (Wilson and Mosher, 1994; Lister, 1998; Danchak et al., 1999; Lister et al; 1999). We call this model the Rensselaer 80/20 Model. The 80/20 Model combines both asynchronous and synchronous learning and connects students, instructors and educational content in rich, online learning communities. In general, about 80% of a student's time is spent on self-paced engagement of online materials and about 20% in synchronous learning sessions interacting with the instructor and other students (Virtual University News, 2000). This paper discusses Web-Based Differential Equations, the first full course developed and delivered in the 80/20 format.

The Development of Web-Based Differential Equations

In 1997 Rensselaer's Anderson Center for Innovation in Undergraduate Education received a Sloan Foundation grant to create four asynchronous learning networks courses: C++, Physics 1, Chemistry of Materials and Differential Equations. All of these courses were being taught in studio style, but Differential Equations seemed particularly well suited for production in the 80/20 format.

The face-to-face version of Differential Equations, developed by William Siegmann, Professor of Mathematics at Rensselaer, is taught in two sessions per week during the semester, each session lasting for one hour and fifty minutes. Class size ranges from 30 to 50 students. Each class period follows the classic studio structure. The instructor begins by reviewing homework and encouraging questions about any problems the students might be having with the course material. As is generally the case in studio courses, lectures are greatly reduced and the instructor follows the introductory question and answer session with a brief (5-10 minute) mini-lecture that develops an important concept and/or technique. The students then work on hands-on exercises that develop their understanding of the topic under consideration. These exercises require the students to solve problems using pencil and paper or the computer program Maple. While the students are working on their own, the instructor and teaching assistant circulate around the classroom answering questions and helping the students reach solutions. Following the hands-on exercise, the instructor reviews the hands-on exercise with the students, clears up any remaining questions, and then moves on to the next topic, repeating once again the sequence of minlecture, problem solving session, and summary.

To produce the asynchronous portion of Web-based Differential Equations, the Anderson Center taped all of the minilectures given by Professor Siegmann during his Spring 1999 class using a Sony DCR-VX1000 digital camera. Following the in-class tapings, each minilecture was edited in Premiere 5.0 and then encoded in RealVideo format and placed on the course web site in groupings that corresponded to the 24 class sessions. The hands-on exercises associated with each minilecture were also placed on the course web site.

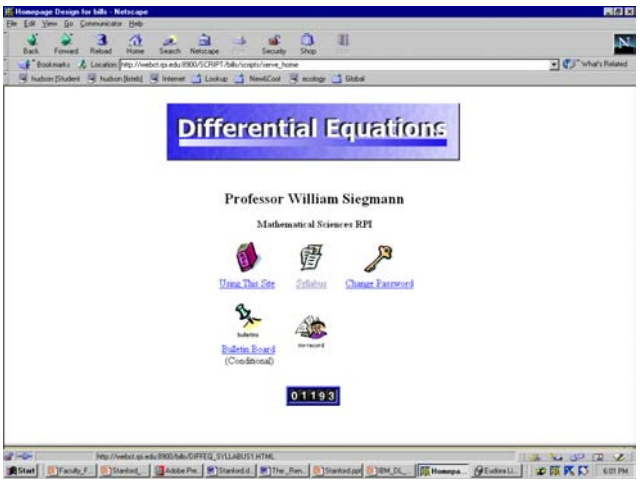

Figure 1. The WebCT home page for Web-based Differential Equations.

Figure 1 shows the home page for Web-based Differential Equations. Each student taking the course logs into the website with his or her username and password. By clicking on Syllabus the students enter the page containing the streaming video lectures, associated hands-on exercises, assignments and related readings (Figure 2). In theory, students taking the web-version of the course would move through each class segment in sequence: introductory video clips followed by hands-on exercises followed by summary video clips. Before the final version of the asynchronous materials was placed online, evaluations were conducted at Rensselaer's Human Computer Interface Lab. Students involved in the evaluations pointed out a number of course components that needed revision including sequencing of video clips, assignments, and instructions for the RealVideo player. Student evaluations also contributed significantly to the online manual for the course accessible by clicking on the Using This Site link on the home page.

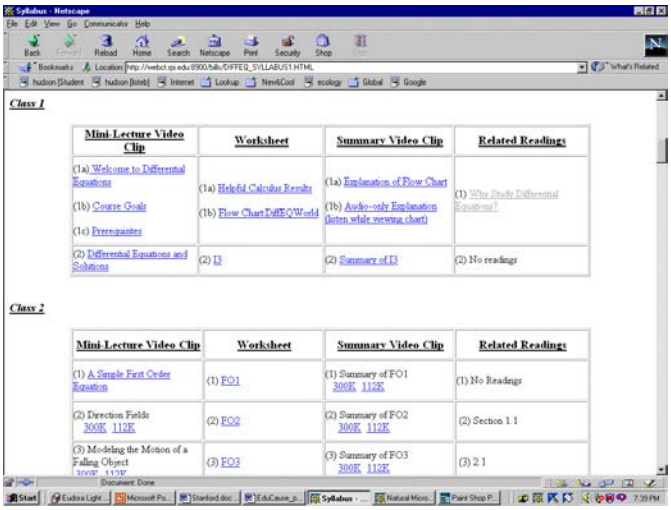

Figure 2. The course syllabus screen for Web-based Differential Equations

The course web site was constructed using WebCT which is now being used by over 200 courses at Rensselaer. WebCT contains a number of tools for enhancing asynchronous learning such as a bulletin board and online quizzes. To date we are making only limited use of the bulletin board for instructor postings and student feedback.

Synchronous Learning Sessions

The synchronous, Web-based sessions for Differential Equations are conducted using LearnLinc, a software system for conducting live, interactive classes over the Internet. Each student in the class has a laptop or desktop computer with a minimum of 64 MB of memory and at least a 166 MHz processor, headphones, microphone, and LearnLinc software. The online instructor is equipped with a 366 MHz IBM 600E laptop with 128 megabytes of memory and a Shure SM2 headset with SM10 microphone. A LearnLinc session begins with the students logging on to the Anderson Center's LearnLinc server via Internet Explorer or Netscape. Once logged on, students are connected to each other and to the instructor in a virtual studio classroom and participate in the session via the student interface screen (Figure 3). Depending on student location and available technology, the interactive session could utilize LearnLinc's digital video and/or voice capabilities for communication. Differential Equations is currently employing LearnLinc's digital voice and text messaging (see Figure 3) for instructor-student communication.

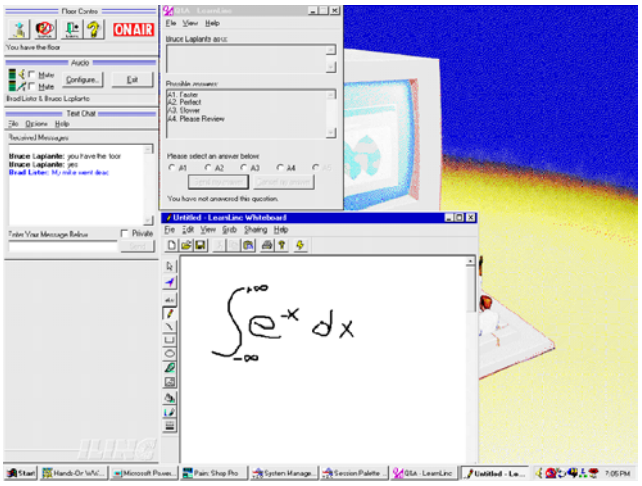

Figure 3. The student LearnLinc screen with the whiteboard tool in utilization.

Once the class is in session, the instructor can activate several LearnLinc tools to emulate the proven techniques of interactive teaching that are so effective in the face-to-face classroom. A particularly important tool in Web-based Differential Equations is the LearnLinc white board. Here the instructor can conduct interactive problem solving sessions with the online students. Several different graphics boards were tested for use with the LearnLinc white board. At the present time we are using a Smart Board SB540 with floor stand (Figure 4). The Smart Board allows the instructor to write equations just as he or she would

do in a regular classroom by applications sharing of the white board within LeanLinc. When the instructor uses different color pens in developing a solution, the different colors also appear on the student screens. Screens can also be saved as digital images for later use. In this way, a series of screens utilized in the development of a solution can be retrieved if needed. Another, less expensive and more portable solution which we have used successfully for writing equations and text on the LearnLinc whiteboard is a Numonics Graphics Master II tablet.

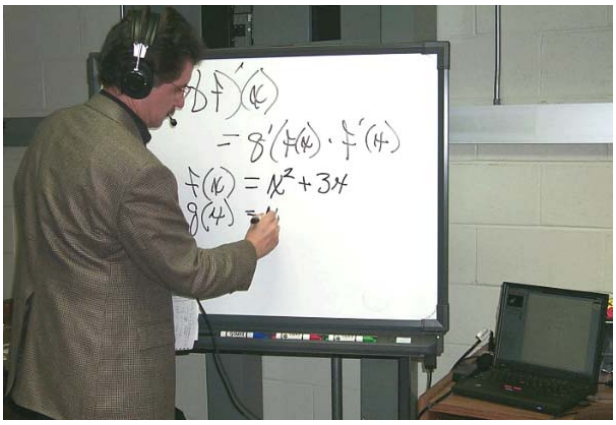

Figure 4. Math instructor using the Smart Board interface to the LearnLinc white board.

During the LearnLinc session, the instructor can also bring up a Question and Answer tool that allows real time interactive quizzing and polling of the online students (Figure 4). An extremely effective tool for interactive distance learning is the applications sharing feature of LearnLinc. Here the instructor can run any Windows-based software program on his or her machine and pass control over to any of the students. The students can then lead the class in running an interactive simulation, demonstration or problem solving session with Maple. Following the format of a typical Studio class, the instructor might then present a brief mini-lecture on new content, sharing PowerPoint slides and multimedia, or using synchronized web-browsing to take the students to web-sites with course-related content. So far, however, synchronized Web-browsing and PowerPoint presentations, while core components of several 80/20 pilots, have received minimal use in Web-based Differential Equations.

Current Status and Future Directions

During the Fall, 1999 semester, Web-based Differential Equations was offered as an alternative to freshman and sophomores taking Bill Siegmann's Studio Differential Equations course. At an information sharing meeting with potential students, the 80/20 Model and the general philosophy and design of the course were covered. We also pointed out that, while the course was indeed a pilot and cutting edge, that it truly represented the future of learning and that they would be increasingly exposed to similar courses during their years at RPI and throughout their lives. The flexibility of an 80/20 course was also emphasized as well as the success of several 80/20 pilot courses that had been developed and delivered by the Anderson Center. Many of the students were reluctant to take an experimental

version of a course which they felt was already difficult and demanding. Ultimately only two students signed up for the Web-based version. One of these students completed the course and received an A while the other dropped out. The fall semester pilot was still encouraging, however, in that Studio Differential Equations certainly appeared to port well to the Web environment and the enabling technologies proved to be robust and educationally effective. Web-based Differential Equations was offered again in the Spring 2000 semester and this time 13 student registered for the course. We have inserted a few new video clips and streamlined the interface in places, but the course is essentially the same. The interactive LearnLinc sessions are now offered for three hours once a week during the evening. We also require that the 80/20 students come to class to take the hour exams along with the face-to-face students. We can track student logons to the WebCT site and so far all of the 80/20 students are logging on regularly and keeping up with the home work. The course teaching assistant (Julie Byrne) sends regular e-mail messages to the students encouraging them to keep up with the assignments and participate in the interactive sessions. At this time participation in the interactive sessions is voluntary. Hence the synchronous component of the course functions primarily as online office hours and help session.

During the spring semester we will be conducting both formative and summative evaluations of the online students. An initial focus group will be held midway through the course and hopefully this feedback will allow us to correct any major problems and make appropriate changes. We will also be carefully analyzing performance on the hour exams and will make any necessary changes contingent upon on the 80/20 students' performance compared to the regular studio section. A final focus group will be held before the end of the semester and an evaluation questionnaire administered. Over the summer we will again review course content and structure and offer Web-based Differential Equations to a larger group of both on- and off-campus students in the Fall of 2000. Meanwhile, we are creating a Web-based 80/20 version of Studio Ecology and improving our production capabilities with the purchase of a Trinity system from Play, Inc. (www.play.com). Finally, we are researching small, cheap ($50-$60) graphics tablets that students could use with their laptops for truly portable interactive problem solving with each other and their instructors. To date none of the products we have tried have worked with our IBM laptops.

In the future we expect the learning environment at Rensselaer, and many other colleges and universities, to include a diverse array of course offerings, from totally asynchronous 100/0 courses to totally synchronous 0/100 courses. Online components of these courses will be accessed via thousands of laptops connected to high speed gigabit networks. Electronic office hours will become routine and students will assume even more responsibility for their own learning as they prepare for deeply interactive face-to-face sessions by engaging a rich assortment of online resources including streaming video minilectures, multimedia exercises, online experiments, large data sets, and digital libraries. How all of this will impact traditional campus-oriented education remains to be seen. Will some students choose to learn almost entirely through asynchronous materials? Will the availability of online courses reduce social interactions and social learning

experiences? Indeed will students still come to class if they can learn just as effectively from the Web? Will the time structured semester system survive? Clearly a number of complex questions confront us as we continue to explore the educational potential of the Internet and online learning. The only certainty is that an exciting new era in higher education truly lies before us.

Literature Cited

Baath, J. 1982. Experimental research on computer assisted distance education. In Distance Education: A World Perspective, Athabasca University/International Council for Correspondence Education.

Barker, B. 1986. Interactive satellite instruction: How rural schools benefit. Annual Conference of the Rural Education Association, Little Rock, AR.

Danchak, M., Jennings, W., Johnson, D. and Scalzo, K. 1999. Teaching and learning in a technological world: The Rensselaer 80/20 model for the working professional. Proceeding, IEEE Frontiers in Education Conference, San Juan, Puerto Rico.

Fulford, C.P. and Zhang, S. 1993. Perceptions of interaction: the critical predictor in distance education. American J. of Distance Education 7(3):8-21.

Glinkowski, M., Hylan, J. and Lister, B.C. 1997. A new studio-based dynamic systems course: Does it really work? Proceedings IEEE conference on multimedia, engineering and education Philadelphia, 1997.

Harasim, L. 1993. Collaborating in cyberspace. Interactive Learning Environments 3(2):119-130.

Kahn, B. 1997. Web-based Instruction. B. Kahn, ed. Educational Technology Publications, Englewood Cliffs, NJ.

Kearsley, G. 1995. The nature and value of interaction in distance learning. Distance Education Symposium 3. The Pennsylvania State University.

Kirby, Elizabeth. 1999. Building interaction in online distance education courses. SITE 99 Internation Conference, San Antonio, Texas.

Kwiatek, K. 1982. Learning from interactive television. J. Educational Technology Systems. 11:117-129.

Lister, B.C. 1988. Interactive technologies for distance learning, in J. Lebaron (ed), Innovations in Distance Learning. NEDLC, Albany, NY.

Lister, B.C. 1998. Interactive distance learning: The virtual studio classroom. Proceedings IEEE Conference on Multimedia, Engineering and Education. Hong Kong.

Lister, B.C., Danchak, M, Scalzo, K., Jennings, W., and Wilson, J. 1999. The Rensselaer 80/20 Model for Interactive Distance Learning EduCause '99 Proceedings, Long Beach, California.

MacKinnon, A., Walshe, B., Cummings, M., and Velonis, U. 1995. An inventory of pedagogical considerations for interactive television. Journal of Distance Education 10(1): 75-94.

McNeil, B. and Nelson, K. 1991. Meta-analysis of interactive video instruction: a 10 year review of achievement effects. Journal of Computer-Based Instruction. 18(1):1-6.

Moore, M. 1989. Three types of interaction. The American Journal of Distance Education 3(2):1-6.

Virtual University News, RPI's 80-20 Model: Some thoughtful ideas on learning design and support services. 2(7): 5-6

Waggoner, M. 1992. Empowering Networks: Computer Conferencing in Education. Educational Technology Publications. Englewood Cliffs, NJ.

Wagner, E. 1997. Interactivity: From agents to outcomes. In Teaching and Learning at a Distance. Tomas E. Cyrs, ed. Jossey_Bass, San Francisco, CA.

Wilson, J. and Mosher, D. 1994. The prototype of the virtual studio classroom. Journal of Instruction Delivery Systems, Summer, 1994.

Wilson, J. 1994. The CUPLE physics studio. The Physics Teacher. 32:518-523.