Integrating Upper-level Undergraduate Students with Graduate Students Through a Video-taped Course in Hydrology

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Abstract

This paper describes the development of a graduate-level hydrology class that was offered in conjunction with a senior-level undergraduate class at WPI. The graduate students enrolled in CE 590 (Special problems in hydrology), with three taking the course on-site, while the remaining eight students taking the course off-site via videotape. The undergraduates in this course enrolled in CE 4061 (Introduction to hydrology) and took the course on-site at WPI. For the undergraduate class, course requirements included individual homework assignments, in-class quizzes, and group projects. For the graduate class, course requirements included homework assignments, take-home quizzes, and an independent project. While the lectures are covered the same material for the undergraduates and graduates, the graduates were responsible for a more in-depth understanding of basic topics and additional advanced topics. A number of efforts using available technologies (including videotapes, US Mail, telephone, email, the World-Wide Web (WWW) and interactive video) were used to facilitate information transfer and enhance the learning experience. Graduate project topics were incorporated into the lectures so that contributed material could benefit all student, and lectures by members of the professional community were delivered via interactive video to incorporate practical aspects and to allow a wide range of students and professional to participate. A field trip to the Wachusett Reservoir (located near the WPI campus), which could easily be attended by the on-site students, was videotaped so off-site students could benefit as well. The use of technologies in the course demonstrate how alternative course delivery options can be used to develop a framework that draws the students on the WPI campus closer to members and applications of the professional community.

1. Introduction

For the last decade, there has been a growing concern that a division exists between the professional community and academia. The university or college typically provides the student with an undergraduate education, and then industry takes over and trains the student for the remainder of the student's career. New approaches are necessary to overcome this division and better prepare both undergraduate and graduate students for their careers after graduation. Fortunately, a number of educators have taken steps toward this goal. For example, Bourham (1997) emphasized the use of research to better prepare undergraduates for post-graduate work, while Middleton and Branch (1996) established collaborative undergraduate-graduate projects to help prepare both undergraduates and graduates for work in a professional environment. Others

have stressed the importance of improved communications and partnerships between academia and the profession as an approach for improving engineering education (e.g. Luthy et al., 1992).

Improvements in communications technologies have led to recent increases in the use of distance learning methodologies. In particular, colleges and universities are increasingly making use of distance learning to provide graduate-level opportunities to working professionals. Courses based on distance learning are typically delivered via videotape, the World-Wide Web (WWW), or interactive video (in which students at a remote site can interact with students at the professor at the home site). Each of these delivery techniques presents its own set of constraints on the educational process. Moreover, the selected teaching strategy and use of the distance learning technologies can create barriers to successful learning (Hillesheim, 1998). Sumner and Tayler (1998), for example, stress the importance of careful design of course products and practices to foster interactive teaching. In addition, Mathisen, Hart and El-Korchi (1998) found that personality type and cognitive style can play a role in effective use of remote communications in group project-work completed as part of an introductory civil engineering course.

While the use of communications technologies for distance learning presents a number of difficulties and challenges, these approaches can also provide the opportunity to enhance undergraduate education through the integration of graduate students and experts from the professional community. This paper describes an integrated undergraduate/graduate course in hydrology that was developed to take advantage of these opportunities. For this course, distance learning technologies were used to enhance education of undergraduates and graduates by drawing on practical applications and experience of professionals and part-time graduate students.

2. Background - The M&E/WPI Partnership

Development of this course was initiated through a partnership between Metcalf and Eddy, Inc.(M&E) and WPI. In 1996, the Civil and Environmental Engineering (CEE) Department at Worcester Polytechnic Institute (WPI) initiated efforts to establish a partnership with Metcalf and Eddy, Inc. (M&E), an established consulting firm in the Metropolitan Boston area. M&E's objectives were to develop a unique training program that would assure that their employees could maintain a high level of technical and managerial expertise. WPI's objectives were to establish a closer link with the professional community to enhance its academic and research programs. The discussions led to the development of the joint WPI/M&E Continuing Graduate Education Program, which included an agreement by both organizations to develop educational activities, information exchanges, and research collaborations. Since the program's inception in 1996, WPI has provided full-credit graduate courses to M&E employees through courses offered on-site at the M&E facility in Wakefield, MA and, more recently, through courses offered via videotape and interactive video. The program is providing graduate opportunities to M&E employees and professionals in the Boston area and other accessible regions. In addition, however, the collaboration will encompass a wider range of activities that will enhance undergraduate and graduate programs at WPI. This hydrology course described in this paper was developed in support these efforts.

Figure 1 – Wachusett Watershed


Figure 2 – WPI's TV Studio

3. Course format

Objectives and overall approach - The course had two basic objectives. The first objective was to provide students with an understanding of the basic principles which govern the distribution and transport of water in the environment. The second objective was to help students learn some basic approaches for developing a quantitative description of the rainfall-runoff process. The Wachusett Reservoir and its contributing watershed was selected as a focus for developing topics that illustrate the role of hydrology. This watershed, which is shown in Figure 1, serves as a vital link in the water system supplying the entire Metropolitan Boston area. The course included a field trip to the Wachusett Reservoir to illustrate watershed protection initiatives, and also included a series of guest speakers to incorporate practical applications on different topics. The format for the course was set up to accommodate both undergraduate and graduate students. Students interested in enrolling for undergraduate credit enrolled in CE 4061(Introduction to Hydrology), while students interested in enrolling for graduate credit enrolled in CE 590 (Special Problems in Hydrology). While the basic lectures were be essentially the same for the two classes, the requirements for CE 4061 and CE 590 varied as necessary to accommodate the undergraduate and graduate course requirements. For example, undergraduates were informed when course material covered advanced topics that they would not be responsible for, and some additional advanced topics were scheduled for classes when undergraduates were on break.

Classroom resources - The majority of the graduate students took the course remotely via videotape, so the course was located in the WPI's TV Studio so it could be videotaped for this purpose. A picture of this TV Studio is shown in Figure 2. This classroom is used for all classes taught in conjunction with the Advanced Distance Learning Network (ADLN), WPI's distance learning program. The classroom seats 48 students in tiered seating. Black-and-white video monitors are located at the student desks and a large 35-inch color monitor is located in the front of the classroom. Lecture materials can be presented via PowerPoint presentation, an overhead document camera, or slides. Classes can be delivered live to appropriately equipped sites using the ADLN's Picture-tel videoconferencing system. The use of digital compressed video allows the instructor and students to have discussions in real time, complete with visual aids and live

demonstrations. Classes were delivered to student homes on VHS videotape. Although class met each week for 1.5 hours sessions on Mondays and Thursdays, tapes were shipped out once per week on Tuesdays, and arrived at students' homes on a two-day-delayed schedule.

The undergraduate class format - The undergraduate class included 12 students, who enrolled on-site at WPI and attended class in the TV Studio. WPI's program normally includes 4 seven-week terms over the academic year (in which each student takes three intensive classes per term). The duration for this course was extended to a full semester so the course could be taught concurrently with the graduate course. The requirements for the undergraduate class included homework sets, two quizzes, and two group projects (worth 30 %, 30 %, and 40 % of the final grade, respectively). Undergraduates took the quizzes in-class with an open textbook and open notes. Group projects were completed in teams of three. The first group project involved the application of basic modeling principles to predict runoff for a small basin in the Wachusett Reservoir tributary area. The students compared their results to real data monitored in the basin, and discussed any similarities or discrepancies between their predictions and data. For the second group project, students made use of water quality measurements (phosphorous and nitrogen species) in conjunction with previously analyzed water quality data to estimate annual nutrient loads to the Reservoir. Students were encouraged to complete Myers-Briggs Type Indicator® (MBTI) surveys to better understand their personality types and learning styles. In this case, these surveys were not used for assessment of the students' performance, and were only recommended to help them in their group work.

The graduate class format - The graduate class included four students taking the course on-site in the TV Studio, and eleven students taking the course via videotape. Most of these students were located in the greater Boston area, although one student was located in Ohio and another was located in Gaza. The requirements for the graduate class included homework sets, an extensive take-home midterm quiz, and an independent project (worth 45 %, 20 %, and 35 % of the final grade, respectively). In most cases, homework problems were similar in nature to the undergraduate problems sets, although additional questions typically were included that were open-ended in nature. The midterm take-home quiz was similar in nature to the undergraduate project in that it involved the application of basic modeling principles to estimate the role of infiltration and evaluation runoff for a small basin in the Wachusett Reservoir tributary area. However, topics for the quiz included more advanced open-ended questions and each student completed the quiz independently. Finally, each graduate student completed an independent project consisting of an 8 to10 page paper in which the student applied (and/or extended) course material to a topic that the student was interested in. This approach provided an opportunity for each graduate student to learn more in an area that could not be covered in course due to time limitations.

4. Communication and information technologies employed

Since the course included both on-site and off-site students with a range of resources available to them, the course made use of a variety of delivery options and communication technologies, including videotapes, US Mail, telephone, email, the World-Wide Web (WWW) and interactive video. Descriptions of the use of these options follow:

Videotapes - As noted previously, all classes were videotaped and VHS videotapes were distributed weekly to students taking the graduate class at remote locations. A class field trip to Wachusett Reservoir, which was easily accessible and well attended by undergraduates, was also videotaped so that off-site graduate students who were unable to attend the field trip could benefit as well.

US Mail – Packages were sent weekly to all students taking the course via videotape. These packages included videotapes, any notices or announcements, and all copies of lecture notes, handouts and assignments. The packages ensured that all students had adequate access to course information.

Email - All students in the course had internet access and email was used extensively to contact students with announcements, clarifications, and requests for information. When appropriate, files were sent as attachments. This mode was especially useful for responding quickly to questions from individual students and quickly distributing the information to other students in the class as appropriate. All students were comfortable with the use of this medium, and, with the exception of one student located overseas, all students used email effectively. In fact, approximately 50 percent of the videotape students also preferred submitting materials via email.

Telephone – Since all students were proficient with the use of email, telephone was not used extensively. Telephone calls were usually used to discuss specific issues or problems, to remind students of due dates, and to discuss questions or clarifications on homework sets or quizzes.

FAX – For printed pages and maps, the facsimile (FAX) was effectively used to distribute materials to individual students. Students who weren't comfortable with the use of email to submit assignments, quizzes or reports also used the FAX to transmit assignments and other materials for the class. Poor quality of material sent by FAX only resulted in a few problems.

WWW - A home page on the World Wide Web (WWW) was established in conjunction with this course at http://cee.wpi.edu/ce4061. This homepage provided descriptive information relating the course's general information and course requirements. While the homepage was under development throughout the course, it also served as mode of communication to facilitate information transfer to the students. This information included lecture notes, homework assignments, answers to questions, links, and announcements and clarifications. The home page also included direct access to a file-transfer-protocol (ftp) site from which students could access any Word documents, excel spreadsheets (with data), and any maps and graphics required for projects and homework assignments. Some graduates and essentially all undergraduates used the home page extensively to access lecture notes and prepare for exams.

Interactive video – Four classes were developed as interactive video sessions to allow students who are off campus to participate interactively in the class. For these sessions, the Picture-tel system and ISDN telephone lines were used to establish a real-time remote connection with the M&E–Wakefield office. Metropolitan Boston area students, M&E employees, and any other interested professionals were welcome to join these sessions. Three of the interactive sessions included lectures by professionals covering relevant topics and applications, and another interactive session was held during the final class so that graduate students could give short presentations summarizing their projects. Most of the students who were able to attend these sessions appreciated the opportunity to interactively view the presentations in real-time.

5. Requirements and constraints

The use of the camera for the videotaped and interactive video classes imposed a number of requirements and constraints for lecture preparation and delivery. Since the videotape served as the primary communication medium for remote students, the presentation of material in lectures effectively required visual aids suitable for delivery within the confines of a television screen. Large font sizes and clearly delineated illustrations were necessary to ensure high quality videotapes, and the characteristics of the videotaping aspect presented difficulties in writing out material by hand during lectures. Since the monitor display of a computer could be recorded directly, Powerpoint presentation software was used to deliver most graphics and lecture notes. Other documents and hardcopies were displayed using the overhead document camera. Preparation time increased because of the effort involved in developing the lecture materials (although this time would likely be reduced for future offerings). In addition, when using these teaching aids, the time to cover material decreased. Therefore, lecture notes were made available so students could use them as a guide for lecture. With the use of Powerpoint and the document camera, only a limited amount of material could be displayed at any instant. This constraint led to some difficulties with displaying large tables in lectures and presenting direct visual comparisons of alternatives (approaches that were used consistently in previous offerings of the same course). In addition to the obvious limitations in class participation and interaction for remote students, interactions with the on-site students were reduced as compared with interactions with students in previous course offerings. These reduced interactions were primarily attributed to the students' reticence in speaking on camera, although it is likely that the adjustments in format to accommodate the videotape format also affected interactions.

6. Enhancements and applications

While the combination of the graduate class and videotaped components in with an undergraduate class presented a number of constraints, the approach also provided opportunities for some unique enhancements for both undergraduates and graduates. First, a field trip to the Wachusett Reservoir Watershed provided undergraduates with some physical perspective on watershed protection as well as the scale of the watershed that they were investigating. By videotaping this field trip, off-site graduate students could learn some about the nature of the area as well as on-going watershed protection efforts (even though they could not fully benefit from the experience of attending the field trip in person). This effort was considered to be valuable since both undergraduates and graduates were required to solve open-ended problems that were related to the Wachusett Watershed. Of course, it must be recognized that the two groups of students inherently approach these problems from a slightly different perspective. For example, the undergraduates in the course are just beginning their careers (and typically have limited report-writing experience), whereas any of the graduate students have already had some practical experience in a professional environment (and are likely more experienced in report preparation). To draw upon these different perspectives, the undergraduate reports were distributed (anonymously) to graduate students. Each graduate student evaluated one report for technical accuracy and content, and also for quality of presentation. Graduate students were then graded for the accuracy and completeness of their review, in order to provide them some additional experience in evaluating the work of others. The useful reviews were then forwarded

(anonymously) to the appropriate the undergraduate groups for their benefit, although the reviews had no bearing on the undergraduate students' grades. By providing feedback from both the professor and a working professional, the approach was intended to help the undergraduate gain a greater awareness of the importance of technical competence and effective report writing.

To establish further linkages with the professional community, interactive video sessions were set up in which speakers from the professional community presented topics introducing some practical applications of hydrology. Topics for these presentations emphasized the relationships between various hydrologic reservoirs (e.g. ground water and surface water interactions). Students and employees at the remote site, as well as a number of students from other sites, attended the interactive sessions, and graduate students who were unable to travel to the remote interactive site still were able to view the presentation on videotape. An interactive video session was also used for the final class, in which each graduate student gave a 10-minute presentation describing his or her individual project topic. The topics generally expanded upon course material and applied it to different problems. Thus, the projects provided graduate students with an opportunity to investigate an individual topic of interest. Each graduate student also provided a short handout to distribute to all other students so that every student would benefit. A number of these topics were developed from actual projects, and all projects were found to be extremely valuable in demonstrating real-world applications to both undergraduate and graduate students.

7. Summary and Conclusions

The hydrology course described in this paper illustrates one approach for using distance learning technologies to enhance both undergraduate and graduate education. The contributions of the professionals and graduate students (most of whom took the graduate course remotely via videotape) enhanced the learning experience of undergraduates (who took the course on-site at WPI) by demonstrating practical applications of course subject matter. These applications included presentations describing on-going projects and research, as well as graduate student presentations describing applications of course material. Additional applications were developed using real-world data developed with a general focus on a watershed located near WPI. These aspects of the course provided opportunities for both undergraduates and graduates to gain background in the theory, applications, and limitations of hydrology.

In summary, the communications technologies used in this course successfully provided a graduate opportunity for off-site students and also provided opportunities to establish a closer link between the course with the professional community. However, the course demonstrated that the use of distance learning does impact the learning process, and additional efforts are needed to further develop the use of these technologies. For example, lecture materials must be carefully developed so that technology effectively conveys material and encourage active learning. In this case, group work was completed at the undergraduate level, but group work was not included at the graduate level due to communication difficulties and time constraints. Some literature suggests the importance of learning style and value of collaborative learning in distance education (e.g. Pendergrass and Sun, 1998; Rafe and Manley, 1997). Additional work is necessary to utilize these techniques and develop project-based courses that promote interactions among students at the undergraduate and graduate levels.

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10. Biographical Information

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