Web-Based Distance Education: Experiences Teaching Material and Energy Balances

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Abstract

The features and advantages offered by the Internet are well suited for providing effective and engaging distance learning experiences. These advantages include: i) convenient access to the course from any location and on any schedule; ii) an added level of communication of the scientific concepts through well-designed audio-visual content (including voice, simulations, animations, pictures, and video); iii) the students' control of the pace of the course; and iv) the ability to easily integrate problem solving with the "lecture" component of each lesson. We have developed a web version of the sophomore-level chemical engineering core course *Material and Energy Balances* that is offered entirely over the Internet. Features of the course include: i) a set of fifty-minute lessons that are delivered using voice, text, pictures, simulations and animations; ii) sets of 10 to 20 short answer questions that the students encounter about every 20 minutes and are designed to reinforce the concepts that they just learned; iii) weekly homework assignments (with posted solutions), iv) regular exams that are administered on campus or by an approved proctor; v) a cooperative group project in which teams of students work together. This course has been taught every semester (including summers) since the spring semester of 1999. Our experience teaching this course for the past five years has shown that the course is effective for teaching the class material, and has enhanced the learning opportunities offered to students.

Introduction

The Internet offers several important advantages for the delivery of college course content, and is well suited for effective distance learning. Foremost, the Internet offers convenient access to the course from nearly any location (any computer with Internet access) and on any schedule (24 hours a day). This is especially important for distance education since it allows students to integrate their course with their off-campus jobs or other activities. In addition, a course

specifically designed for the Internet can be more engaging and interactive than printed educational materials. Indeed, the features offered in a multimedia computing setting can be used to create a highly effective learning environment through well-designed audio-visual content. A well-designed Internet course can provide an added level of communication of the scientific concepts through carefully planned audio-visual content (including voice, simulations, animations, pictures, and video) that can be continuously updated and improved. Finally, an Internet course allows each student to control the pace of the course to suit his or her unique style of learning, and allows student problem-solving time to be easily integrated with the "lecture" component of each lesson. This can be especially important for engineering courses in which it is through the act of solving problems that the students do most of their learning.

Course philosophy and approach

The recent proliferation of college courses offered on the Internet has shown that there are different philosophies regarding style and structure of these courses. The simplest approaches involve posting lecture notes or slides on the Internet, or filming traditional classroom lectures to make them available over the Internet. These approaches essentially use the Internet as an alternative venue for dissemination of information in the same format as a traditional textbooks or lectures. While these approaches allow Internet courses to be developed quickly and therefore have the advantage of expediency, they do not utilize the unique educational advantages offered by the Internet. In contrast, we tried to use the features offered by multimedia computing to create an added level of interactivity and communication beyond simply posting notes or slides. Students progress through the course at the same pace they would progress through the traditional lecture version of the course (two Internet lessons per week). Each lesson is designed to take roughly an hour to complete and is delivered using voice, text, pictures, simulations and animations. About every 20 minutes, the student encounters a set of 10 to 20 short answer questions that are designed to reinforce the concepts that they just learned. The student reads each short question, then develops her brief answer (a few words, a number, *etc*) before clicking on the "Answer" button to access a pop-up screen with the solution. Printable transcripts of the audio narration are available for each lesson, and the Web pages are formatted for easy printing. In this way lessons are structured to support different learning styles as well as hearing impaired students. We anticipate that most students will find it most effective to use both the audio and the video components; however, students can obtain all of the educational material in the lesson without using the audio.

Cooperative Group Project

Engineers are increasingly required to use the Internet to work together from remote locations. For this reason, it is important for students to begin developing their communication skills in this relatively new medium early in an engineering curriculum. To meet this need, the course includes a cooperative learning group project called the "People Balance Project" in which the students work together in interdependent groups of five, with each group member assuming a different role essential to the success of the project. Since the project is delivered and implemented on the Internet, a group may include members from different sections of the course, different universities, or even different countries. In the project each group of students collects data on the people entering and leaving a "system" of their choice (which may be a building, a portion of a building, a plot of land, *etc.*), then uses this data to perform both differential and integral people balances to test a hypothesis they had formulated previously. The following aspects of the project require effective teamwork to be successfully completed: i) defining the role of each team member, ii) choosing a compelling "system" for study, iii) formulating a postulate to be tested experimentally, iv) developing an experimental plan for data collection, v) coordinating the team's effort to collect the data, vi) analyzing the data to test the postulate, and vii) reporting the research results to the rest of the class through a report on the Internet. This project is designed to enhance team skills and requires the students to find effective ways to communicate with one another from remote locations.

Lessons Learned Regarding Web-Based Distance Learning

Our experiences with the web-based course in material and energy balances illustrate both the tremendous promise and the potential problems associated with the Internet for delivery of college courses. Foremost, there is every indication that the course is effective for teaching material and energy balances. The feedback from the students has been positive, and the performance of the students in the subsequent chemical engineering courses has been at least as good as those who took the traditional lecture version of the course. For example, in the most recent offering of *Chemical Engineering Thermodynamics* (the next course in the program sequence), roughly half of the students had taken the web version of *Material and Energy Balances*, while the other half took the standard "lecture" version of the course. The students who had taken *Material and Energy Balances* on the web averaged approximately a quarter of a point higher for their final grade in Chemical Engineering Thermodynamics.

The widespread access and availability afforded by the Internet has clearly provided scheduling flexibility which has enhanced the educational opportunities for students. For example, nearly 90% of the students who have taken the course would have been unable to take a "standard" lecture version of the course because they were off campus (on a co-op work assignment, home for the summer, *etc*), or because the lecture version was not offered (at Iowa, the lecture version is available only in the Fall semester). The availability of the web version of the course in the Spring and Summer semesters is especially useful for students who are transferring into the Chemical Engineering program, and nearly half of the students who have taken the course at the University of Iowa have been transfer students. This is particularly important since Material and Energy Balances is the first major course in the curriculum, and serves as a prerequisite for many of the subsequent courses in the program.

Web delivery of college courses is clearly different than the traditional lecture format, and therefore has its own issues and potential pitfalls. The largest difference between course delivered on the Internet and those delivered in the traditional classroom arises from the fact that the course does not have a regular meeting time, and therefore relies on each student to have the individual initiative and the discipline to monitor their e-mail communications and to keep up with the prescribed course schedule. The most common failure mode for the course involves students who do not take ownership of the course in this manner. To help prevent this occurrence, it is important to maintain contact with the students with regular e-mail messaging and occasional phone calls. In addition, occasionally (~once every two or three semesters) a student finds that the web course is not well suited to their learning style and chooses to drop the course. The vast majority of the students find the course to be engaging and effective.