The Development of an Internet-based Environmental Engineering Program at the University of Missouri

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Abstract *- The University of Missouri-Columbia is delivering graduate environmental engineering courses over the Internet. These semester length classes incorporate group student projects, self-directed laboratories and direct faculty-student contact. To date, six classes have been modified for Internet delivery. Internet classes allow great time flexibility for part-time students, and an educational opportunity for students distant from the university.*

Introduction

The University of Missouri-Columbia (MU) is committed to the development of a complete, high quality Internet-based graduate Environmental Engineering program (http://www.missouri.edu/~ceewww/courses/online.html). Courses offered through the Internet follow the same semester system adopted at MU. The classes consist of units of instruction that have preset starting and ending times. However, the student has the freedom to decide when to participate within the unit. The limited asynchronicity is essential to allow a high degree of interaction between student and instructor, and among students. Another positive aspect of the Internet-based program is the capability to have guest experts at any given class or to conduct a class with two or more instructors located at distant locations, even at different time zones.

The orientation behind the MU program is to provide students-at-distance with a high degree of interaction with the instructor. This is perhaps the single most important feature of the MU Internet-based education. The MU experience reveals that Internet students have better access to, and get more personalized attention from their instructor-at-distance than their counterparts on campus. The literature reports similar observations from other education-at-distance programs and the explanation might be the same: instructors dedicate their time to interaction with students because lecture materials are provided ahead of time.

The MU program supports the integration of laboratory and field experiences in the Internet classes. An example is presented in this paper. There are only few attempts to replace the actual lab experiences with computer simulations. Students take exams at their site under the supervision of approved exam proctors.

The Internet-based Environmental Engineering graduate program at MU still is under development. However, at this time the classes offered each semester already provide a viable alternative to the conventional academic education.

Background

Increased demand for higher education is rising and should continue rising as the pace of technological changes in our world continues to expand. Better and faster communication options are becoming available to developing nations worldwide promoting the need for education and technology to compete in a global marketplace. This environment benefits those education centers that can provide high quality education and easy access to students. Why would anyone enroll at a neighboring college or university if they can get better, or at least the same education, from a more widely recognized university that takes advantage of the new communications technology and offers courses at distance? The personal interaction between instructor and student is certainly the most widely recognized value in a traditional setting. However, when student:faculty ratios become high, interaction and its value are reduced.

Education is a commodity valued by its quality. Quality in education is defined by the contents of classes, mode of delivery, and availability of supporting information and services to complement the course. The new millennium will bring additional demand for skilled labor represented by new professionals and by professionals already in the job market that will need to keep up with new technology. A possible alternative to meet this demand for education will be to build new centralized universities to operate along traditional guidelines. The other alternative is to develop education programs that will take advantage of the new communication technology, particularly the Internet, to deliver courses at distant locations, at the workplace or at home, on demand.

Overall issues concerning Internet-based teaching have been addressed [2,7]. Bourne *et al.* [2] discuss the differences between classroom and on-line teaching issues in terms of the materials used, role of laboratories, ability to have peer learning, etc. They also provide an overview of the different network learning models (i.e. learning modalities, asynchronous methods, synchronous methods, semi-

synchronous methods, interactive learning, and instructor interface) and the degree to which different educational objectives can be achieved based on which model is used. Wallace and Mutooni [7] present the results of an experiment on the effectiveness of WWW vs. classroom instruction. They developed a WWW-based equivalent of a 90 minute lecture then compared the performance of 21 students who received the material in the traditional classroom format versus 15 students that received the material via the WWW. The results of their experiment show that the WWW students tended to be more effective than classroom lectures.

Internet Education-at-a-Distance Issues

Instructor-Student Interaction

Internet education-at-a-distance should always include interaction between the instructor and student through the Internet. The MU model is based on units of instruction that have a pre-established beginning and ending, thereby establishing a high degree of student commitment to the program. The model provides for limited asynchronicity to accommodate a wide range of student time availability to go through the course material (within a limited time frame, e.g. one week). Alam and Rencis [1] discuss how the Internet can be used to enhance and encourage student collaboration through either e-mail or groupware software. Collaborative group work [4] can be executed when the students are moving through the course synchronously. At some pre-defined times during the program, exams will require student access to established locations. This can be done easily if the students are concentrated in areas with easy access to a central examining location.

Faculty interaction

The concept of education-at-distance will require the establishment of a global education network comprising a number of education centers qualified to provide the facilities needed by student testing. This arrangement is possible for universities that have established agreements with similar entities statewide, nationwide or globally. These entities will be central locations or action nodes in a large education network. A course in a given subject could be a catalyst to establish working relationships among a number of faculty.

The action node concept in education-at-a-distance is a key factor to promote faculty interaction at all scales. At a time when local issues can be associated with local and perhaps even global problems, there will be definite advantages to teaching with the support of a wide research network. There is a definite value in providing instruction on a subject with the possibility of showing a wide range of applications, not only locally but globally.

Laboratory and field classes

Laboratory and field experiment classes are a challenge to education-at-a-distance. Many courses in engineering and other fields include not only fact-based material which is provided to the student as text, but also design projects where real-life problems are solved by students and hands-on laboratory experiments which require special kits and in many cases dedicated laboratories. Design projects require a great deal of instructor-student interaction and benefit greatly from student-student interaction. Much of this can be handled through the Internet.

One significant issue that is often raised in the context of engineering education is: how are laboratory experiences incorporated within a Internet-based course? One approach has been to develop simulations (i.e. Singh *et al*. [6] for the analysis of semiconductor band structure of silicon), another approach has been to allow for control of remote lab equipment via the Internet (i.e. Henry [3] for a process control laboratory and Knight and DeWeerth [5] electronic test equipment laboratory).

Laboratory-based classes provide a major challenge to education-at-distance. One approach to some laboratory experiments is the development of lab kits that are sent to students. The CE393 course (below) had a substantial laboratory requirement which was handled very well at distance. Another approach would be to develop a lab program that could be carried at action node locations with the participation of local faculty. The same approach would be taken for field experiment or field classes. Local faculty involved in the program would participate in planned field work.

Example Internet Class

CE393 Environmental Engineering Microbiology was one of the first Internet engineering courses produced by the College of Engineering. From the outset, the instructor was committed to integrating real laboratory experiences in this Internet class. One of the requirements for enrollment was that each student have access to a light microscope. It was anticipated that microscope use would be less than one hour per week, so that students could use equipment at locations such as water treatment plant laboratories or medical clinics. The laboratory kits provided to the students included: prepared and clean microscope slides, Millipore test kit, immersion oil, lens paper. A video was prepared showing the details of coliform testing and algal assay. A VHS tape was provided to the students: in the future, these video segments will be provided on a CD with links from the WWW pages.

The usual laboratories included in the face-to-face class were evaluated for their learning value in the course.

Essential laboratories for both courses included: total coliform bacteria testing, algal identification, and Gram stain identifications. Other laboratories were deemed optional, and would only be included in the Internet class if they could easily be modified for unsupervised use. The coliform testing was accomplished with a Millipore® Coli-Count Swab Test Kit and appropriate directions for where samples could be obtained.

The algal identification exercise requires a live algae sample for viewing, so several photomicrography views of a live sample were presented on the WWW pages. A binary identification algae key was provided as part of the text materials. The students were first guided through four identifications with other photomicrographs — just as it would have been done in the classroom.

The Gram stain identification laboratory was completed by the students with their microscopes, but without the Gram stain liquids. Prepared slides with three different smears were included in the laboratory kits. The students had to identify the Gram type and cell shape from the slide, which meant that they had to be capable of focusing a microscope with immersion oil.

The students had to prepare laboratory reports on algal assays from furnished data, complete calculations, draw conclusions, and specify engineering remedies to nutrient inputs.

Class size

The student:instructor ratio can be fairly well defined for a traditional class, but what should be this ratio for an Internet-delivered course? When course quality is an issue, it is reasonable to expect that a student:instructor ratio similar to what is practiced in the traditional classroom should apply. Internet course delivery, however, provides an opportunity to the educator to reach a much wider audience. The basic issue in reference to class size is the ability of the instructor to interact with the students, that is to answer questions and to discuss related topics.

Another approach is to work with faculty at active node institutions to handle the interaction with a larger number of students. Another options that could reduce the need for direct instructor-student interaction is to encourage cooperative learning between students. Other alternatives to handle a large number of students will certainly come up as more students consider taking Internet delivered courses.

Quality Control

The quality of an Internet course will depend on course content, pedagogy, and appropriate technologies. The courses produced to date by MU Engineering have been subject to peer review by outside content experts and distance education specialists. New technologies are introduced to the faculty by an on-campus distance education unit. Integration of emerging content, pedagogy and technology are essential to providing an excellent distance education program.

Future Plans

- MU Engineering will continue to expand its Internet environmental engineering offerings.
- Innovative solutions to laboratory and pedagogical challenges will be sought.
- Cooperative agreements with other universities will be pursued to create action nodes.

References

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