EXPERIENCES IN TEACHING ENGINEERING COURSES THROUGH THE INTERNET

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ABSTRACT

Teaching engineering courses using the internet requires exploring pedagogical and technological techniques that are unique to such courses. Without a sound pedagogical basis, courses offered through the internet will become mere online textbooks and will not enhance students' learning. Further, in classroom-based delivery, faculty have the opportunity to motivate and inspire students, answer spontaneous questions, stimulate critical thinking through discussions, and monitor students' progress. The technology necessary for internet-based courses also require some unique considerations in the design and delivery of those courses.

In this paper, internet-based delivery of two engineering courses, namely, Information Systems, and Project Management will be discussed. The author was one of the first faculty at Northern Illinois University to teach a web-based course for credit. As part of this pioneering effort, a variety of live instructional techniques and course-specific issues were explored. These courses were chosen for internet-based delivery primarily due to the opportunities they presented for investigating issues such as student and faculty preparation, selection and use of technology tools, internet-based delivery of modeling concepts and mathematical formulations, coordination of virtual classroom meetings, handling of laboratory exercises, online testing and grading, management of interactions with students, and design of special course evaluation procedures. Both courses have been offered through the internet several times during the past six years and several assessment instruments have been specifically designed to evaluate a number of issues related to the internet-based delivery of these courses. Results of these evaluation procedures and experiences gained from teaching these courses using the internet are discussed in detail in this paper along with a number of recommendations on internet delivery of engineering courses, including course development, faculty and student preparation, institutional support, and useful information on tools and techniques available for teaching through the internet.

1. INTRODUCTION

Teaching through the internet can take on many forms as faculty can deliver courses through a variety of ways ranging from using the internet as a supplementary resource for posting course materials to delivering courses fully. How effectively internet is used for teaching can be

impacted by course preparation, course design, delivery, assessment, institutional support, and other related factors. STEM (science, technology, engineering, and mathematics) courses may especially have additional factors to consider due to the laboratory or clinical experience components and the use of equations and graphical images. In some cases, STEM courses may also be more suited for teaching through the internet due to the process-oriented nature of many of the courses which require students to learn step-by-step approach to solving problems.

I was one of the first faculty at Northern Illinois University (NIU) to teach a credit course online during summer 1998, and during the past 6 years, I have taught the courses "IENG482 Engineering Information Systems" and "IENG442 Engineering Project Management" several times online. Both courses are open to upper division undergraduate and graduate students in engineering, business, and other disciplines. These two courses were chosen for online delivery as they require students to complete only software-based laboratory assignments in MS-ACCESS or MS-Project, do not require physical laboratory assignments (as in the case of manufacturing courses), and the course topics are suitable for upper division or graduate students to be motivated to be responsible for their learning process in an online environment.

In this paper, teaching through the internet is used synonymously with teaching online, and the working definition of an online credit course at NIU is that it "has at least 80 percent of its instructional activities conducted through the Internet, and satisfies the guidelines for online courses in the *Academic Policies and Procedures Manual* (Northern Illinois University, 2003). This definition is consistent with the definition of online courses at many universities in U.S. (The Sloan Consortium, 2004). As per this definition, the two courses chosen for online teaching involved 80% or more of its instructional activities conducted through the internet, and the remaining 20% of instructional activities were conducted face-to-face on campus, and these included first class introductions, midterm exam, final exam, and class project presentations.

The activities conducted face-to-face were decided based on logistics, cost, technology limitations, and academic integrity reasons. For example, exams were conducted face-to-face on campus to ensure academic integrity, but conducting them online would have required designing individualized exams or complicated logistical arrangements to ensure academic integrity. Similarly, project presentations were made face-to-face in class, but delivering them online would have required video/audio components or advanced interactive technologies which many students did not have. From both faculty and students angles, conducting these activities face-to-face simplified the effort for everyone involved and required students to visit the campus only for those face-to-face activities. On the other hand, requiring students to visit the campus for these face-to-face activities meant that only those students who lived within driving distance from the campus could take these courses. The following sections describe briefly the preparation, design, delivery, assessment, and support aspects of these two online courses successfully delivered at NIU, and the lessons learned from this experience.

2. COURSE PREPARATION

One of the major differences between a face-to-face course and an online course is the amount of upfront preparation necessary for an online course. In a face-to-face course, faculty can do a

number of things spontaneously with basic tools such as a marker and a writing board, but in an online course spontaneity has to be tempered with considerable course preparation. Online course preparation involves three components: (1) faculty preparation, (2) course materials preparation, and (3) student preparation. The level of faculty preparation can impact the other two components as faculty will have to prepare the course materials and their students.

Faculty preparation includes technology skills necessary for preparing the course materials, course activities and delivering the course, developing the ability to manage students and interact with them in an online environment, and learning the features of the web-course management system (if one is used). These issues may vary with each course, the resources available for faculty in their institutions, and some of it may come with experience as in the case of managing students in an online environment. In my case, I had more than 2 years of experience in designing materials for the web, preparing digital images for posting online and online chat, before I attempted to teach online. This preparation helped me considerably to be self sufficient in designing and delivering courses online and managing students in an online environment.

In a face-to-face engineering course, a faculty can spontaneously write an equation or draw a figure on the board to explain a concept, but in an online course all the necessary figures and equations have to be prepared ahead of time and posted online so that students can view them or faculty can display them in the virtual classroom while going over related concepts. This requires considerable planning, preparation, and anticipating what types of questions students may ask during an online class. In the project management course, I had to prepare separate figures to go over each step of constructing an activity network for a project or the PERT computations, and in the case of the information systems course, I had to prepare separate figures to show the sequence of steps in constructing a process model or a data model so that students could comprehend the development process logically.

When preparing course materials, especially figures or PDF documents, file size and how students generally access the course website should be taken into consideration. Large files should either be compressed or divided into smaller files for ease of downloading and viewing. It is equally important to check ahead of time the course materials are viewable in a variety of browsers as students may use different browsers and some browsers or particular versions of browsers may not display certain documents as expected. It is preferable that the course materials are viewable in a majority of browsers, and if a particular browser or its version or specific plug-in or player is required for viewing an item, then students should be informed ahead of time about such requirements.

Student preparation involves ensuring students have the basic technology skills to interact with the course website and have access to the technology tools for completing the course activities, the communication skills to interact with the faculty and fellow students online, and the necessary study skills to learn in an online environment. A majority of today's students may be technology savvy, but their technology experience may be more with games and hand-held technologies, but not with online courses. Their interactions with friends and peers in an IM (Instant Messaging) environment may not also be appropriate for an online course. Some students may not even have the necessary hardware and software and internet connectivity to

access and interact with the course website. Their expectations about the course, the responsibilities of the instructor, and their own study habits may often be unrealistic.

Before students registered for my online courses, they were informed about hardware, software and connectivity requirements, and course expectations. My information systems course required students to use MS-ACCESS and the project management course required students to use MS-Project. Both these products were also made available in the college computing facilities in case some students did not have the access to these products. An informational document on learning and interacting in an online environment was posted ahead of time on the course website, and the information was also reviewed during the first class of each semester. Tips on communicating effectively and professionally in an online mode was also reviewed and posted online. In addition, I clarified my responsibilities as the course instructor, and who students should contact in case of technical difficulties with the course website or their course accounts, and what the class should do in case of major technical difficulties. This level of preparation reduced possible confusion and anxiety for everyone involved with the courses.

3. COURSE DESIGN

One of the hidden benefits of teaching online is that it forces faculty to pay more attention to course design to teach effectively in an online environment. Courses delivered primarily face-to-face often have to be redesigned for online delivery and the teaching principles have to be matched with technology tools (deVry & Brown, 2000). While many faculty may apply well known instructional design models such as the Dick and Carey (1990) model or pedagogical techniques such as the Kolb Learning Cycle (Harb & Terry, 1992) in designing their face-to-face courses, designing a course for an online environment require additional considerations related to the use of online technologies for delivery and interactions.

The first step in course design is to define the instructional objectives for the course and this will help in designing the appropriate course components to meet each objective and select the necessary delivery strategies. The course components may involve faculty covering appropriate concepts in the virtual classroom, students reviewing the course materials and completing the required course activities such as homework, quizzes, etc., faculty and students interacting through course discussion board, etc. But each of these components has to be designed properly and introduced at the appropriate point during the course so that the course is student-centered and promotes active learning. Defining the instructional objectives and designing the course accordingly also simplifies assessing students' learning.

Depending on how students are expected to learn, the course may have to be designed accordingly. For example, an online class may meet live frequently in a virtual class as in the case of my courses, or a class may meet sparingly in a synchronous mode and students and faculty may meet often in an asynchronous mode. Therefore, appropriate design of course content, activities, and assessments is critical to facilitate student learning.

Both the information systems and project management courses had clearly defined instructional objectives and learning outcomes, and the Kolb Learning Cycle was chosen as the pedagogical

basis for the course design. Each quadrant of the cycle was covered through appropriate course components such as lectures, discussions, homework assignments, quizzes, projects, etc. The lectures were designed to be delivered live in the virtual classroom every week, and the course activities were designed to engage students actively in the course and motivate them to interact with each other. Course materials such as course syllabi, notes, assignments, project information, etc., were prepared and made available in Word or PDF formats.

4. COURSE DELIVERY

Online courses can be delivered in a variety of ways ranging from use of the internet as a supplementary resource for posting course materials to delivering the course fully online. Figure 1 shows the range of delivery possibilities in an online course. The selection of delivery strategies depends on a number of factors such as the availability of online technologies, faculty's familiarity with the technologies, suitability of the technologies for delivering particular course components, time available for developing particular course components for delivery, students' accessibility of chosen technologies, etc.

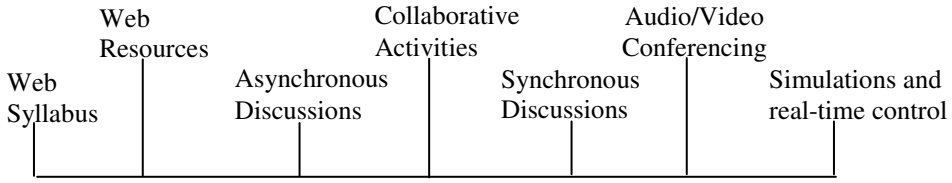

Figure 1: Range of delivery possibilities in online courses (Krishnamurthi, 2000).

Both the information systems and project management courses were delivered using the Blackboard™ web-course management system available at NIU. All the course materials, including course notes, syllabi, assignments and solutions for assignments were posted in course folders in Blackboard. The live classes were delivered in the virtual classroom every week and all the students were required to join the virtual discussions where I discussed course concepts and engaged students in posting and responding to questions in the chat room. The browser in the virtual classroom was used to post digital images or equations related to particular concepts and the text window was used to post messages to explain the concepts or interact with students. Figure 2 shows a sample screen capture of a virtual classroom session.

During each virtual class session, the messages and the digital images were displayed and students were engaged in a discussion. This was quite a challenge to prepare these message scripts and figures ahead of time and modify them slightly during the virtual class and post them in the chat room. The discussions had to be structured tightly such that not everyone posted messages at the same time, and the discussions were moderated carefully to maintain the pace of the class. Students were given adequate instructions on how to post questions or respond to my questions during the discussions. The messages also had to be interspersed with humor to keep the students engaged in the discussion. The discussions held in the virtual classroom were also archived and made available on Blackboard, and students liked this feature very much as it allowed them to review the virtual classroom discussions again and again.

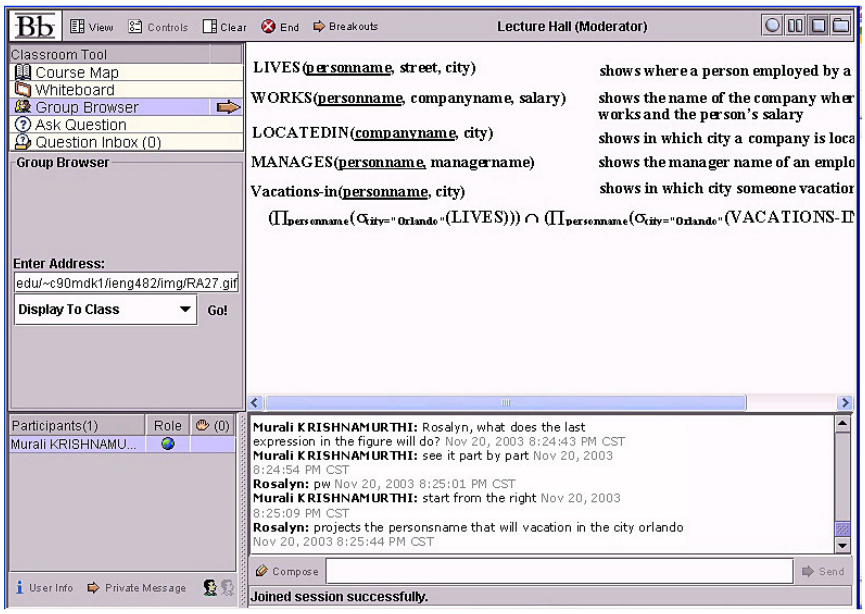

Figure 2: Sample screen capture of a virtual classroom session.

The discussion board in Blackboard was also used for asynchronous discussions and students posted their questions or responded to questions there. Figure 3 shows a sample screen capture of a course discussion board. The group feature in Blackboard was used to assign collaborative activities to project teams and each team had its own discussion board, group email, and chat room to discuss and complete team assignments and projects.

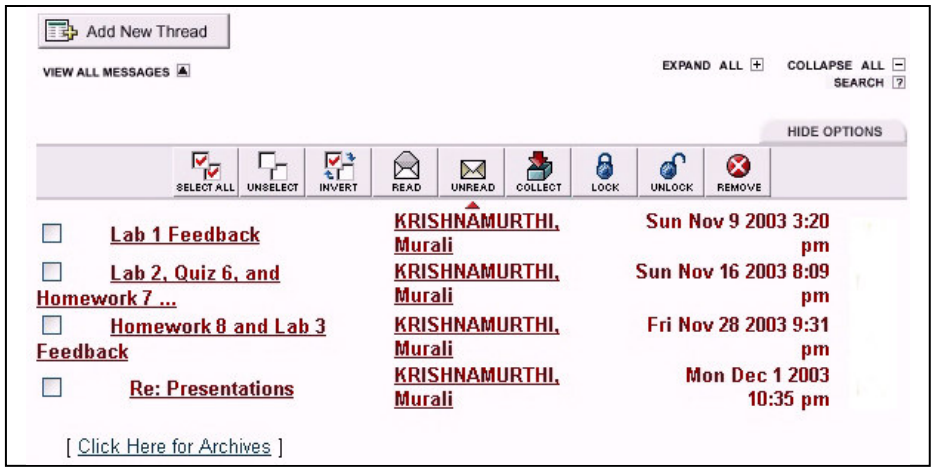

Figure 3: Sample screen capture of Discussion Board messages.

5. COURSE ASSESSMENTS

The assessment components used in a face-to-face class often have to be tailored for an online environment. Some assessment components such as homework assignments could be directly used in an online class. But assessments components such as quizzes, exams, and project presentations require rethinking and redesign for online delivery. In a face-to-face class, students

can present their projects orally with the aid of slides or overheads, but in an online environment the same would require multimedia technologies. Similarly, exams conducted in a face-to-face class would be difficult to authenticate in an online environment to ensure each student is completing his/her own exam. Web-course management systems such as Blackboard have online quiz features but they are useful only for multiple choice, fill in the blank or true/false questions. In STEM courses, faculty are more interested in testing students' ability to demonstrate their process knowledge in solving problems, and not just the final answer. Therefore, online testing features available in web-course management systems have to be tailored appropriately for use in engineering courses.

In both the information systems and project management courses, courses assessments included weekly homework assignments, online quizzes, computer assignments in MS-Access or MS-Project, midterm and final exams, and class projects. All the homework and computer assignment problems were posted on Blackboard and students submitted their solutions through the Digital Drop Box. The graded assignments were also returned with feedback to students through the Digital Drop Box. The online quiz feature was tailored for appropriate use in both courses. Some problems were broken into smaller problems and were designed as multiple choice or fill in the blank questions for students to respond online. In some quizzes, students were asked to solve problems which required simple computations or brief written responses, and submit their answers back. This allowed for testing students on their process knowledge of solving problems. These quizzes were timed and all the students were required to take the quizzes at the same time to prevent any cheating. One of the nice features of the online quiz component in Blackboard is its automatic grading of multiple choice type questions.

The midterm and final exams had to be scheduled face-to-face as those exams required students to solve detailed problems which could not be accomplished online. These could have designed similar to take home exams given in face-to-face classes, but take home exams usually require more effort to design and grade. The project presentations had to be scheduled in a face-to-face class at the end of the semester, and each project team was required to present its project details for the class.

6. INSTITUTIONAL SUPPORT

Teaching through the internet requires institutional support for faculty as well as students on a number of issues. Faculty need help with learning web-based course management systems such as Blackboard, enrolling students into those courses, and issuing login access and passwords to students. Many of the features of web-course management systems are not necessarily intuitive to learn, and sometimes software limitations prevent faculty from customizing their courses as they would like to do. For example, Blackboard does not allow faculty to save digital images of figures and equations in course folders on Blackboard and display them in the chat room during a virtual class. The images have to be stored on another server outside of Blackboard, and then displayed using the browser feature in the chat room for all students to view them. Apart from help with the chosen web course management system, faculty also need help with other technologies such as the software for creating digital images for the web, PDF files, etc.

Institutional support is also needed to assist students with obtaining or updating their logins and passwords to the web-course management system, finding out about hardware and software requirements for accessing the web-course management system, and help desk support in case of technical problems they encounter during a course. It will be impossible for faculty to assist every student with their technology problems, and therefore, technology support is critical.

Both the information systems and project management courses would not have been possible without the hardware, software, and technical support provided by NIU. Along with making Blackboard available for my courses, the college technical staff and university information technology helpdesk assisted me and my students on a number of issues throughout the courses. The technical issues ranged from simple login problems on Blackboard to complicated problems with the virtual classroom, and all these problems were resolved by the technical staff or alternative solutions were offered. Office of Registration and Records at NIU also handled course enrollments and students enrolling in a course or dropping a course were updated in my Blackboard course every night.

Institutional support should also extend to other issues such as online course enrollment and faculty recognition and rewards. Online course enrollments have to be smaller (approximately 20 students) than for face-to-face courses as it is difficult to manage large classes in a virtual environment. There are misconceptions that one of the benefits of online courses is the possibility of enrolling a large number of students in those courses, but online courses with large enrollments are difficult to manage from both learning and technology standpoints. In my courses the enrollment was limited usually to 20 to 25 students.

Finally, institutions should recognize and reward faculty developing and delivering online courses as such courses require time and effort to plan and prepare, experiment with innovative pedagogical and technological approaches, and deal with a variety of problems that do not exist in face-to-face courses. My online courses required at least three times more time and effort for smaller class sizes compared to face-to-face delivery of same courses with larger enrollments.

7. LESSONS LEARNED

My experience in teaching engineering courses through the internet has been very successful, and also positive from the standpoint of my professional development. I designed a special student evaluation form to obtain students' feedback on their online learning experience and my teaching in the online environment. This evaluation was conducted in addition to the regular course evaluation form completed by students for all courses. The results from the special evaluation were very positive on both aspects and a majority of students indicated that they would be interested in taking more online courses. Students' performance in the online courses was not any different than their performance in the same courses delivered face-to-face. Table 1 indicates a sample of results from the evaluation conducted for one of the online courses.

My online teaching experience also resulted in a number of lessons and insight which may be of benefit to other faculty interested in teaching through the internet. The following is a sample of such lessons and insights:

Table 1: Sample of Feedback from the Student Evaluation Form (n=22).

Evaluation Item	Very Good	Good	Average	Below Average	Not Applicable
Instructional approaches used by the instructor for presenting the course material online were	81%	19%	0%	0%	0%
Instructor's availability for consultation outside of class through Discussion Board, email, etc., was:	86%	10%	4%	0%	0%
Instructor's ability to present the course effectively material in the online class room was:	86%	14%	0%	0%	0%
Instructor's ability to use online resources demonstrated in this course were:	86%	14%	0%	0%	0%
Use and balance of online class time for teaching and discussing the subject matter were:	67%	24%	9%	0%	0%
The structure and the format of the discussions during the online chat sessions were	43%	57%	0%	0%	0%

1. Planning and preparation are crucial for delivering a successful online course. It is essential to allocate adequate development time to design the course, develop the materials, and experiment with the course delivery system and strategies. Last minute preparation or spontaneous attempts during an online class may result in technical problems or pedagogical difficulties. In my courses, each hour of a virtual class required anywhere between 3 to 5 hours of advanced preparation, especially if the class required preparing figures and equations as digital images to display in the virtual classroom.

2. Students must be informed in advance about course requirements, protocols for interactions in an online environment, and be offered a formal introduction to the technologies used in the course. Some of the problems experienced by students in my courses had to do with inadequate hardware they had or local ISP difficulties they had, but not with course requirement, communicating in the online class, or inability to use Blackboard.

3. Today's students may be technology savvy when it comes to games and hand-held devices, but not necessarily with learning in an online environment. Students need help with understanding how to learn and interact in an online environment to complete an online course successfully.

4. Clear definition of course objectives and outcomes will help to identify and design appropriate course components. Without course objectives it will be difficult also to assess students' performance. In my courses, the course objectives helped students recognize the need for particular course components and helped me in designing particular assessments.

5. There is no one particular delivery strategy that is appropriate for all online courses. Faculty must decide on appropriate delivery strategies for online courses based on a number of factors including one's own comfort level, availability of technologies, and course needs. My ability to teach live every week online may or may not translate well to another online course taught by another faculty.

6. Course activities designed for an online environment should motivate students and promote active learning. Students generally need incentives for participating in online activities such

as posting or responding to messages on a discussion board, and it is important that faculty also participate in these activities instead of expecting students to participate on their own.

7. Designing assessments for an online engineering course requires careful consideration and creative design as many of the testing tools available on web-course management systems may not be suitable for assessing comprehension of problem solving steps. In addition, conducting exams in an online course may require addressing academic dishonesty issues.

8. Technology support is critical for the success of online courses as faculty and students engaged in online teaching and learning need help with a number of technology issues. Faculty teaching an online course will not have the time to take on the additional burden of helping students with their technical problems.

9. Institutional commitment and support are needed to recognize faculty who develop and deliver online courses as more time and effort is needed to design and deliver online courses. Institutions must also understand the limitations of online courses, especially the limited enrollment essential for delivering online courses successfully.

10. Designing and delivering courses online not only improves faculty's technology skills but also improves teaching skills as online courses are more student-centered than face-to-face courses. In my own case, teaching online has helped me to pay more attention to course planning and preparation, and has improved my teaching of face-to-face courses.

REFERENCES

deVry, J. R. and Brown, D. G. (2000). A Framework for Redesigning a Course in David G. Brown (Ed): *Teaching with Technology*, Anker Publishing Company, Boston, MA.

Dick, W. and Carey, L. (1990). *The Systematic Design of Instruction*. 3rd Edition, Harper Collins Publishers, New York: NY.

Harb, J. N., and Terry, R. E. (1992). Teaching Through the Cycle: Application of Learning Style Theory to Engineering Education at Brigham Young University. Department of Chemical Engineering, Brigham Young University.

Krishnamurthi, M. (2000). "Enhancing Student-Teacher Interaction in Internet-Based Courses," published in the proceedings of the 2000 ASEE Conference held in St. Louis, MO.

Northern Illinois University (2003). Working definition of online courses for procedural purposes. Provost's memo dated July 28, 2003 to deans, chairs, and directors.

The Sloan Consortium (2004). Entering the Mainstream: The Quality and Extent of Online Education in the United States, 2003 and 2004. Report at http://www.sloan-c.org/resources/thanks04.asp. Accessed on 11/27/2004.