Experience with Online Delivery of an Engineering Technical Elective Course

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Abstract – MIE 515, *Alternative Energy Systems*, an engineering technical elective course open to senior undergraduates and graduate students, was delivered as an on line course for Fall 2011. This is the first time an undergraduate engineering course at the University of Toronto has been offered online. The course is also one of five pilot online courses across the University. The move online is being accomplished in two steps. For Fall 2011, a small lecture section of 25 students was used as a setting for video capture and the remaining 110 students accessed the course lectures online asynchronously. A live tutorial was offered once a week. All students were physically present for the midterm examination and the final examination. For Fall 2012, the course will be delivered entirely online, with the exception of student physical presence for the two examinations.

Pedagogical and technical lessons learned during this transition year will be presented. The benefits and drawbacks of online delivery will be discussed from the perspective gained this year and compared with our expectations. Student feedback will also be presented and discussed.

Keywords: Online course, video capture, engineering technical elective, alternative energy systems

1. INTRODUCTION

MIE 515, *Alternative Energy Systems*, is an engineering technical elective course that has been taught annually since the winter term of 2002. The list of topics covered has evolved significantly over the years and now includes solar energy, wind energy, wave and tidal energy, energy storage, and grid connection issues. The field is continually evolving, so the course material must be refreshed each year to stay current. The course serves three distinct groups of students, each with different backgrounds and needs. Fourth year undergraduates are the largest group, about 100 in 2011. Students in the professional MEng Program, twenty in 2011, constitute the next largest group. For this group, MIE 515 is a core

subject to obtain a Certificate in Energy Studies. Finally, there are MASc and PhD students, 15 in 2011, who want to take the course in support of their research. As a result of their sheer numbers, undergraduate dominate the course, to the detriment of the other two groups. Addressing the needs of all three groups through customization was a strong motivation to explore the use of online technology.

The move online is being accomplished in two steps. For Fall 2011, a small lecture section of 25 students (all graduate students) was used as a setting for video capture. The remaining 110 students, including all of the undergraduates and the remaining graduate students, accessed the course lectures online asynchronously. A live tutorial was offered once a week. All students were physically present for the midterm examination and the final examination. For Fall 2012, the course will be delivered entirely online, with the exception of student physical presence for the two examinations. This paper describes the technology used and the experience gained delivering the course in Fall 2011.

2. OVERALL STRUCTURE AND COURSE DESIGN

Until Fall 2011, the course was taught in the traditional lecture format. There were two 1.5 hour lectures each week and a one hour tutorial, all scheduled in the early evening to facilitate access for part-time students in the professional MEng Program. For 2011, the same lecture arrangement, i.e. two 1.5 hour lectures per week, was maintained for the small lecture section used for video capture.

In preparation for the online delivery of MIE 515, the book “Building Online Learning Communities, Effective Strategies for the Virtual Classroom,” was instrumental in recognizing the essential goal of achieving a community online of all students [1]. However, the context of the book is entirely humanities and social sciences, disciplines in which only words are exchanged. The challenge was to facilitate discussion and exchange in an engineering course where symbols, formulas, and sample

calculations are involved. The essential first step in creating the online community was to provide regular online activities that required student participation. For the first year trial, a mix of traditional problems sets (submitted, marked and returned online) and discussion boards were used. Each of these will be discussed in turn.

3. ADVANCE ACTIVITIES

A welcome video that introduced the online course and explained how it would be conducted was recorded and posted to the University of Toronto Portal course management system (Blackboard) in August. As well, a much expanded course syllabus was also posted simultaneously to provide details on course organization and marking scheme. About 5% of the students had questions, but on the whole the video and syllabus were effective in introducing the new course format.

4. LECTURES

Lectures are the primary source of information in the course as there isn't a suitable textbook. A supplemental reader [2] is recommended to students, but as a source of additional context rather than technical content. The lectures were organized into modules on specific topics (Table 1). Each module covered fundamentals, the technology used, environmental and economic issues, and a case study. For some topics only a single lecture was required but other modules had as many as four lectures. The Echo 360 Video Capture system was used to record the lectures. The recorded videos received minor editing and then were posted to the course Blackboard, generally within 24 hours of being recorded. Students could choose between three formats: a streaming video (Rich media), a Vodcast download, or audio only. Whereas much of the previous version of the course was delivered at the chalkboard, a document camera was utilized for the online lectures to provide a higher quality image than could be obtained from video capture of the chalk board. A second advantage is that the notes written out on the document camera provided a written record of the lecture as delivered. After each lecture, the document camera notes were scanned and posted on Blackboard along with the video.

Students took considerable time to view the lectures. The number of times the video was accessed for a representative lecture (November 15th) is shown in Fig. 1. It took until November 30th to reach the number of hits

equivalent to the number of students in the class, but many of the hits shown are multiple hits by the same person. Particularly noteworthy is the spike in viewing in mid-December just prior to the final exam on December 21st. It is clear that we have a long way to go to achieve regular engagement by the students.

Table 1. Module and Lecture Organization

Module	Lec	Lecture topic
Introduction	1	Energy Overview
Radiation Heat Transfer	2	Directional and spectral characteristics
	3	Blackbody radiation
	4	Surface properties
Solar Radiation	5	Atmospheric losses
	6	Sun-earth relations
	7	Estimation of terrestrial solar radiation
Solar Collectors	8	Simple models of solar collectors
	9	Solar heating systems
Passive Solar	10	Passive solar concepts
		Planning for passive solar
Solar Thermal Power Generation	11	Technology and case studies
Solar Photovoltaic	12	Photovoltaic fundamentals
	13	Equivalent circuits and characteristics
	14	Case studies
Wind Energy	15	Technology fundamentals
	16	Wind sources and influences
	17	Predicting wind turbine output
	18	Case studies
Wave Energy	19	Wave energy fundamentals
	20	Wave energy converters – case studies
Tidal Energy	21	Fundamentals and devices
Energy Storage	22	Energy storage technology
	23	Energy storage applied to transit systems
		Hydrogen energy storage
Grid Connection Issues	24	
Future of Renewable Energy	25	Summary and future prospects

Figure 1. Online viewing of November 15th lecture video – hits per day.

5. TUTORIAL

In past years, the course instructor solved some example problems on the board and then opened the floor for general questions. In a sense, the tutorial served the purpose of office hours but with questions and answers heard by all present. The example problems and their solutions were posted on Blackboard, so the tutorial was optional. The current generation of students was raised with the Internet so it would be logical to assume that they would be enthusiastic about an online course. There was, however, some pushback when the move online was announced. The following excerpt is representative:

"I feel that on-line lectures (at least the way I picture them) take quite a bit away from the learning experience and it's unfortunate that students who picked this course ... have to live with this option. I, for one, would dread to drop this course (particularly since I need it for my environmental minor), but I am quite uneasy with on-line lectures."

Thus, for 2011 a live tutorial was retained, so that the online cohort had some opportunity for face-to-face interaction with the instructor. The attendance was quite high at the beginning of the term, but steadily declined as the students learned to make use of online alternatives. Thus, for the transition year, the live tutorial was successful in reassuring students that their questions would be answered.

With respect to online interaction, a "General Questions" discussion board was initiated at the beginning of the course, with the intent of creating an online forum to respond to broader issues, such as technical glitches or administrative questions. In addition, the original plan was to create a separate forum for each lecture so that students could pose questions specific to that material. This was duly implemented for the first and second lectures, but quickly abandoned after they received only 1 and 2 posts respectively. In practice, the students posted all of their questions on the "General

Questions" discussion board, no matter what the topic. Despite being told to post questions to the discussion board rather than send individual e-mail to the instructor, many students still sent e-mail. When this occurred, the instructor posted credible questions received by e-mail on the General Questions discussion board along with a response, without identifying the student. On the whole, participation in the General Questions discussion board was very low, only 44 students with 144 posts over the entire term. The low participation may have been due to the live tutorial but a clearer explanation of how questions are to be posted (and answered) will be necessary for fall 2012 when the course is entirely online. It should be noted that of the questions that were posted directly to the discussion board, most were answered [correctly] by other students. This suggests that there was a nucleus of the desired online community, although it never grew beyond a small group of students. So, there is both hope for but also a challenge to creating an online community in Fall 2012.

With the online course, there is a need to be able to respond online to student questions thoroughly and

Figure 2. Mini-tutorial example.

promptly. The use of formulas and sketches necessitates a response with images as well as text. Using features of Echo360 capture software or Apple Quick Time, it was easy to create a mini-tutorial explaining the theory or concept in detail. For example, a formula or a diagram can be written out on paper (a passive solar problem example is shown in Fig. 2) using a document camera to capture the process, while at the same time recording a verbal explanation of the solution as a voice-over. The result is then posted to the discussion board.

The advantage of this technology is that the instructor can, without the assistance of a technician, create an audio-visual response to questions. Our hope is that in the next iteration of the course a comparable (and inexpensive) technology can be developed that would enable the students to communicate in a similar fashion. This would really move development of an online learning community forward.

We are also exploring the possibility of implementing a live online session at a scheduled weekly time in place of the previous tutorial. Once again, the document camera would be the enabling technology for an audio-visual response, even if the student questions are written rather audio visual themselves.

6. TERM WORK

Students had to submit some type of assignment weekly as a way of keeping them up-to-date on the lectures and to provide practice with the material. The assignments were in two forms: discussion board participation and problem sets.

6.1. Discussion Boards

Since this was the first time discussion boards had been used, students were given the opportunity to participate in 3 discussion boards, but only the best two marks were used and these together accounted for 4% of the final course mark. Discussion board participation was marked using a rubric (developed by others in the Faculty of Applied Science and Engineering) that allocated 2 marks each to Contribution to Knowledge Base, Relevance, Collaboration, Clarity of Communication and Quality of Feedback. The rubric was provided to students in advance of their participation in the first discussion board.

There are two places in the course where discussion boards fit well: at the beginning of the course when only introductory material had been delivered and students were not yet able to solve problems, and at the end of the course where a number of topics, e.g. energy storage and grid connection issues, don't lend themselves readily to problem sets. To get students started, each student was asked to introduce themselves on a discussion board and

state what they hoped to get from the course. Participation was quite good as 132 of 140 students initially enrolled responded.

The Ontario Provincial Election provided a great context for the first marked discussion board, which was posted immediately after the introductory lecture. Students were provided with links to the election platforms of the three main political parties contesting the election and asked to discuss how the party platforms addressed some of the issues raised in the first lecture. Participation was low, only 83 of 136 students (61%) responded. Those that responded did well (average 8.4 out of 10) but quite a few students didn't understand what they were supposed to do and simply didn't participate. Even among those who responded there was relatively little discussion – people posted individual comments independently, often starting new threads on the same topic. The lesson was that students need a relatively detailed set of instructions for participating in a discussion board.

For the next two marked discussion boards, both near the end of the course, more specific instructions were provided and the responses were significantly improved. The context for the second marked discussion board was the NIMBY problem, something that came up frequently in case studies presented in lecture. Students were asked to discuss how, in the context of renewable energy, to balance the rights of individuals against a potential societal benefit. A controversial proposed wind farm was provided as an example. Finally, near the end of the course, the students were asked for the third marked discussion board to discuss which renewable energy technologies have the greatest potential to contribute to Canada's energy needs. The second and third marked discussion boards had participation from 95 (70%) and 110 (81%) students respectively. Marks on these two were nearly identical, 8.6 out of 10.

In the end, 5 students didn't participate in any of the discussion boards and another 7 responded to only one discussion board. We are trying to follow up and understand why these students essentially threw away marks – was this through misunderstanding or is there some impediment to their participation, e.g. poor language skills or simply shyness? It is clear that we need to do more next year to achieve full class participation in the discussion boards.

6.2. Problem Assignments

The problem assignments were designed to give the students practice using the concepts learned in class and also to encourage them to explore the behavior of various renewable energy systems, e.g. by performing a sensitivity analysis and plotting their results. Some problems were made up in response to student questions.

For example, questions from students showed that they were having difficulty understanding the tradeoffs between fluid outlet temperature and flow rate in a solar collector. Assignment #4 therefore asked them to explore this tradeoff with a simple numerical model. Problem assignments were posted on the course Blackboard and students submitted their completed assignments online. Marked assignments were also returned online.

7. SIMULATION AND ECONOMIC ANALYSIS

Economic rather than technical issues are the weakness of most renewable energy technologies. In order to provide the students with a realistic understanding, each student was asked to analyze the performance of a proposed wind turbine installation for an off-grid power system on an island off the coast of Newfoundland. The simulation is not numerically challenging – at the level of an Excel spreadsheet, but students have to choose from multiple procedures and data forms to carry out the simulation. Using the projected electricity output for the system, the students had to estimate the cost of power production and conduct a sensitivity analysis to establish which parameters have the largest influence on costs. The simulation and economic analysis was 10% of the final course mark.

8. EXAMINATIONS

A midterm examination and a final examination (30% and 40% of the final mark respectively) at which the students were physically present constituted the largest portion of the student's course mark, consistent with normal course practice and faculty regulations. The midterm exam was held in the early evening for the convenience of part-time graduate students.

9. CHALLENGES ENCOUNTERED IN FALL 2011

A number of technical difficulties were encountered that challenged the students and tested the patience of the course teaching assistants (with such a word).

9.1. Lecture Capture

On the whole, the lecture capture worked very well. However, some lessons in reliability were learned very quickly. The video camera used had its own recording capability, which provided a backup to the Echo 360 Capture hardware. Despite having two parallel systems, the voice recording component failed after only a week of

classes. This necessitated re-recording two lectures in an alternative format and introduced a nearly one week delay in posting lectures. The students were remarkably patient as long as they were kept informed of the progress. For the remainder of the term, an independent voice recorder was used to provide a third backup for the voice component.

9.2. Assignment submission

Students were required to submit problem sets online. There was no common technology for doing so and this resulted in huge files – e.g. camera images of homework pages – being submitted. This presented challenges for Blackboard and for the subsequent marking process. For Fall 2012, arrangements have been made for scanners to be placed in the library for use by on-campus students. Most individuals don't have access to a scanner, so use of cameras will be still part of the process for at least off-campus students. An Information Engineering colleague has pointed us to a number of smart phone apps that create a compact pdf file from a cell phone camera images. These are being evaluated with a view to specifying their use when a camera is used in lieu of a scanner. This would support specifying that all assignments be submitted in pdf format, which would resolve the issues around submission.

9.3. Assignment Marking

Submitted assignments were downloaded to a tablet PC for paperless marking. The assignments could be downloaded as a batch from Blackboard, although the large file sizes made this process more time consuming than it needed to be. Marked assignments were uploaded to Blackboard for viewing by students. Unfortunately there is no provision for batch uploading to Blackboard so this was a tedious procedure, complicated by inconsistent file names. For Fall 2012, a required file naming convention will be implemented for all assignments to minimize time spent uploading.

9.4. Interaction

Part of the difficulty is a technology problem in facilitating this type of communication. We are investigating hardware and software that might make it easier for students to quickly submit hand calculations and sketches that might move discussion along. We plan to incorporate the most convenient technology we can find into the Fall 2012 course structure.

10. PLANNED IMPROVEMENTS

The following changes are planned for Fall 2012 to address issues identified from the Fall 2011 experience:

1. An introductory online tutorial covering online learning technology. Students employ all sorts of devices and software, but there is a need for technology that interacts well with our Course Learning Management Software (currently Blackboard) to minimize frustration and time spent accessing the system.
2. The lectures will continue to be delivered in asynchronous mode since some graduate students taking the course are part-time students with full-time jobs. They need the flexibility of choosing a time to watch the lectures. However, the course instructor will offer a live online question session, likely in the evening for easy access by the part-time students. This will allow students to ask lecture questions that they would have asked in a live lecture. It will also allow students to ask questions about the problem sets. In both cases, the live online session provides a second option to asking questions on a discussion board.

11. CHALLENGES FOR FALL 2012

Comments received from the small group of students who attended the video capture lectures were particularly interesting because they had both options open to them. Their views were mixed. Contrast:

“online lectures very helpful and very convenient
... making whole course online better idea,”

and

“I enjoyed the lectures and felt that the online component worked quite well. Earlier in the term I was able to attend only ½ of the lectures per week but there was no detrimental effect to my learning due to the online lecture videos,”

with

“I like the dynamics of the in-class environment. A little disappointed to hear that the class will be 100% online in the future,”

and

“I am happy that I could follow the course in class because one learns so much more than when watching just a video. I prefer having an in-class course much to an online course.”

The students like the freedom to choose the viewing time, as well as the ability to review lectures multiple times. The challenge for Fall 2012, is to provide them a timely and simple means of asking spontaneous questions and then sharing the questions and responses with the entire class. Our focus for Fall 2012 will be on developing a scheduled online session to facilitate this process.

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