AC 2008-850: ME350 REMOTE EDUCATION: EXPERIENCES IN TEACHING ENGINEERING TO NON-ENGINEERING MAJORS STUDYING ABROAD

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ME350 Remote Education: Experiences Teaching Engineering to Non-Engineering Majors Studying Abroad

Abstract

This paper examines the development and implementation of a remote, asynchronous mechanical engineering course taught to seven non-engineering majors. The students studied abroad in five countries on three continents and in four different time zones. The content of the course includes topics in the areas of Fluid Mechanics, Thermodynamics, and Heat Transfer. Particular emphasis is placed on how the ME350 remote education model affects resource allocation, student performance, and student perception of the learning experience. Because course content between the resident and remote formats was nearly identical, a meaningful comparison of student time spent per lesson is addressed, showing that overall, students spent similar amounts of time on the course, regardless of the venue. A significant issue for remote students was reliable communications with the host institution. Internet connectivity varied widely based on student location and could not be adequately assessed prior to implementation of the program. Key learning points associated with this experience are addressed. The course director conducted a personal time survey which revealed that approximately two hours were spent in development of remote course content for every hour of student utilization. Anonymous student time surveys also indicate that both resident and remote students devote a comparable amount of their time to the course. Regardless of venue, all students took the same final examination at the host institution under controlled conditions. Remote students performed better than local students on the final examination, but, overall course grades were comparable. Exit survey results indicate that remote students completed the course with a more positive perception of their learning experience when compared to their counterparts. A concise list of lessons learned that has been shared with the United States Military Academy Center for Teaching Excellence and International Affairs Office is included.

Background

As the U.S. Army strives to be more culturally aware, the United States Military Academy (USMA) has put renewed emphasis on the enrichment of student education through the semester abroad program. The goal of the Academy is to have approximately 15% of all students spend a semester in a foreign country. The emphasis equates to approximately 150 students studying abroad per year.[1] The greatest percentage of these students come from the Department of Foreign Language, not from the Department of Civil and Mechanical Engineering (CME). As a part of the USMA curriculum, all students not enrolled in an engineering major are required to take a 3-course core engineering sequence. This core sequence can be in a number of engineering disciplines: Civil, Mechanical, Electrical, Systems, Environmental, Nuclear, and Computer Science. Despite the fact that a majority of students studying abroad come from non-engineering majors, CME must ensure that its "non-majors" are afforded the opportunity to complete their graduation requirements in the federally mandated 47 months. Remote education is becoming an ever increasing component of meeting this stringent timeline. CME taught its first remote education course in the fall of 2005[1]. Since that time, four additional courses in the department

have been taught via remote education. ME350, Introduction to Thermal Systems with Army Applications was one of those four courses.

ME350 is the second of three courses in the Mechanical Engineering core engineering sequence. Students typically take ME350 in the spring of their junior year, after completing their first engineering course, CE300, Introduction to Engineering Mechanics and Design. ME350 covers general topics in Fluid Mechanics, Thermodynamics, and Heat Transfer. It is a unique course not typically found at other universities.

In late September of 2006 the Department of Foreign Language identified three students that would require ME350 as a remote education course in the spring semester of 2007. These students were slated to study in two countries. Although the original estimate of remote education enrollment was three students, the number swelled to seven by Lesson 1 in January. The number of countries correspondingly increased to five: China, Egypt, Germany, Spain, and Russia.

All of the students enrolled were juniors majoring in foreign language. Collectively they held an average Total QPA of 3.46. While this was one of the primary criteria used by the Department of Foreign Languages to select students for inclusion in this program, the ME350 faculty were concerned with the preparation of these students for the study of highly technical subject matter in the absence of readily available assistance. The ME350 faculty surveyed student performance in three of the prerequisites for ME350: Calculus II, Physics II, and Fundamentals of Engineering Mechanics and Design. Table 1 lists a synopsis of student performance in these courses, their combined grade point average in academic, military, and physical areas, and their final course grade in ME350.

Table 1. Student Performance in ME350 Pre-Requisites

Student	GPA	Mechanics	Calculus	Physics	Course
1	2.635	B-	B-	B-	B+
2	3.588	A-	B+	A	A+
3	3.06	B+	B	B-	A-
4	3.143	B	C+	C+	INC
5	3.786	A	B	A	B
6	3.682	A-	B+	A	A+
7	3.196	B+	A-	B+	A-
Remote Average	3.299				
Course Average	3.04				

The student with the lowest Physics and Calculus grades (student #4 in Table 1) dropped the course around lesson 10. This student cited Internet connectivity issues as well as the need for additional “personal” interaction with the instructor as primary contributing factors to lack of success in the course. It should be noted that this student’s Internet connectivity issues were no different than those of student #6, who was located at the same foreign institution. Student #6 was able to successfully complete the course with an A+.

As the current course director and previous course director began planning the delivery of this remote education course, assumptions were made that all students would have some form of Internet access and that they would be spending the majority of their time studying at their home university and minimal time (mainly weekends) traveling throughout the host nation. This was a poor assumption.

Design of Course Presentation

Presentation of the ME350 course provided a unique set of challenges based on the locations and expected Internet connectivity of the students. In addition, the short time available to develop course content provided more challenges. Based on an assumption of poor or intermittent Internet connectivity, it was determined that course presentation should entail minimal bandwidth requirements to ensure all course materials were useable for the students.

Course content was to be delivered via a course webpage. At USMA, courses are required to maintain an Internet "Blackboard" site, so Web based content is not a new concept for the students. Because the USMA domain operates within Department of Defense (DOD) firewall protection, access to the USMA internal Web was not possible from non DOD computers. In addition, active blocking of U.S. military sites was expected in some of the foreign locations. These two issues rendered the ME350 "Blackboard" site useless for remote education course presentation. Instead, a remote education website was established through Web space provided by a civilian organization outside the DOD firewall.[2]

The ME350 course taught at USMA consisted of 40 lessons. In order to logically organize lesson content for remote education, 40 lesson folders were established on the website. Each folder contained the lesson title and lesson objectives developed in accordance with Bloom's taxonomy.[3,4] A copy of "Lesson Notes" were also provided which were a scanned copy of the course director's board notes used during classroom instruction.[4] The lesson folder also contained solutions to worksheet problems and practice problems.

In order to capture in-class demonstrations, lab procedures, and worksheet solution processes, video clips of lesson content were also posted. Due to the bandwidth issues experienced by a number of students, full lesson video files proved too large to be useful. Instead, video clips were limited to strictly demonstrations, worksheet solutions, and laboratory demonstrations, limited to sizes between 9 and 15 MB. Supplemental materials such as PowerPoint presentations were posted. Homework assignments and lab packets were posted to the website in the folder corresponding to the lesson in which they were assigned to the resident students.

The preferred assignment submission technique was email containing scanned copies of the student's handwritten work. Due to a lack of access to reliable scanners, most students took digital photos of their assignments and emailed those. One student faxed all assignments to the instructor. Both scanning and faxing proved to be fairly reliable methods of assignment turn-in. The digital photo option proved to be additionally time consuming for the instructors. Grading time for assignments was easily doubled as instructors were forced to edit/paste the photos into documents with legible resolution. Feedback was given to the students by scanning and emailing

the graded assignments back to the students. Graded assignments routinely exceeded the 9 MB email limit imposed by USMA. Excessively large assignments had to be emailed in two to four smaller pieces.

The original intent of the course director was to post all homework solutions to the website once all students enrolled in the course had completed the assignment. This proved possible early in the semester, but, as the remote education students' schedules began to diverge, so did their assignment turn-in times. Ultimately, homework solutions for the resident students were made available through the internal "Blackboard Site". Solutions for remote education students were emailed along with their graded assignments.

Based on this course presentation strategy, the remote learning students received identical content as the resident students with one minor exception: the Engineering Design Project was slightly modified to strictly engineering analysis, no actual fabrication was required. Point totals for the assignments were adjusted accordingly.

Resource Allocation

Based on the model used for the development of remote course material, the intent of the remote education version of ME350 was to make the course as resource efficient as possible. Some success was achieved in the fact that the course was conducted using essentially identical material. The dichotomy arose in the resource of time. The amount of additional time required to teach the course via distance education became prohibitive. The resource of Web space was a known issue from the start of the course. The final website took up over 1.62 GB of space.

In order to provide timely feedback and personal attention to the remote students, the three USMA instructors divided the seven remote students among themselves. The two instructors each instructed two of the students and the course director instructed three. The remote students were asked to email a brief lesson synopsis to the instructor for every lesson. These summary emails provided the instructors the ability to keep track of their students' learning while also forcing the students to synthesize the lesson material into a succinct description. The remote students were also given the initial guidance to maintain the same lesson schedule as those enrolled at USMA (1 lesson every two days). Within in the first five lessons of the semester, one of the instructors was forced to hand-over the instruction of his two students to the course director, citing time constraints as the major issue. The instructor felt that he could not devote adequate time to the students in order to provide an acceptable learning environment. The course director devoted additional time to the instruction of these two additional students.

In order to gain a better understanding of the course director's time spent in remote education tasks, a personal log of time spent was kept starting at lesson 10. The course director's individual time survey is shown below.

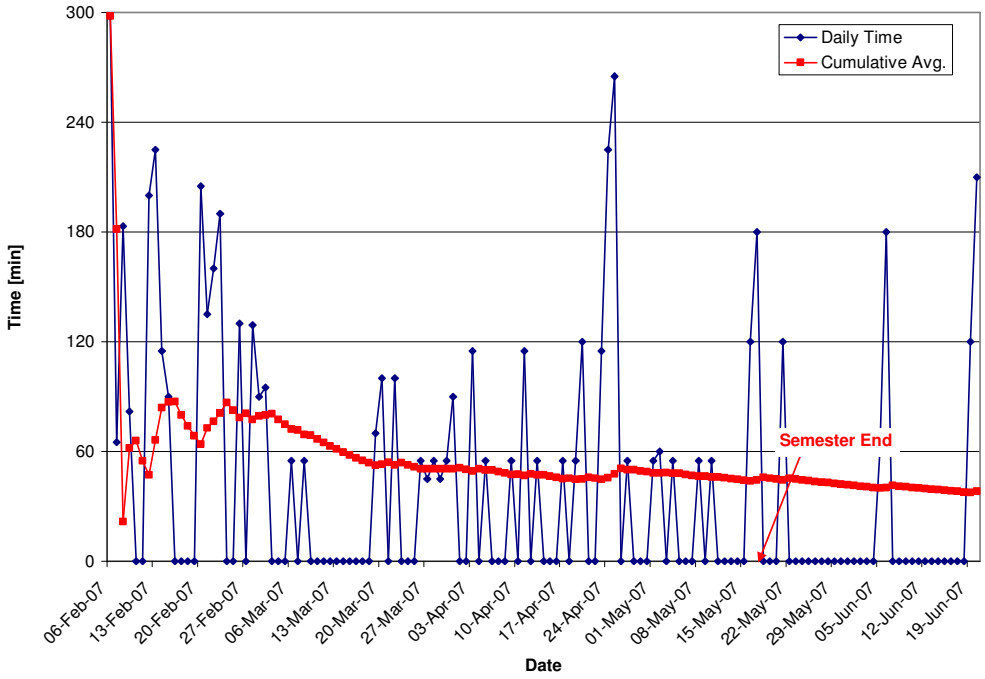


Figure 1. ME350 Course Director's Remote Education Time Survey Academic Year 07-2.

The course director was personally responsible for the instruction of five remote students in addition to teaching three resident classes (46 students). The time commitment shown in Figure 1 encompasses all aspects of running just the remote education class (email correspondence, downloading assignments, grading, and Website maintenance, video capture/editing, etc.). The course director was provided no additional technical support for the Web development or video editing necessary to run the remote education course. As shown in Figure 1, the average daily time commitment spent on the remote education course decreased throughout the semester, stabilizing at approximately 45 minutes per day (including weekends and holidays). This is attributed mostly to becoming more familiar with the maintenance of the course website and video editing software. In addition, due to the remote students falling behind in the course, their required lesson summaries degraded significantly, becoming almost non-existent by lesson 35. This greatly reduced daily email correspondence time.

The remote education course lasted approximately 30 days longer than the resident semester due to the students overseas transitioning from their university experience abroad directly to an overseas military training assignment prior to returning to USMA for the final examination. In order to verify the efficacy of the remote education experience, all remote students were required to complete a final examination, under the supervision of the course director at USMA. The resident and remote examinations were nearly identical, with differences mainly in the values of given information for calculation problems. Due to the conflicts between military training assignments and academic requirements unique to USMA, the remote final examination was administered on three separate occasions.

Figure 1 includes the 55 minutes spent on each lesson attending a fellow instructor's lecture in order to record the video content necessary for the lesson. What is not covered by this time survey is over 20 hours dedicated to the development of the course website shell, which occurred prior to the beginning of the semester. Based on the overall time dedicated to the administration of the remote education course, the development time ratio for the content of the ME350 course was significantly less than estimates for other remote education courses.[6,7] A reasonable estimate is between 2 and 3:1. In some regards this estimate vindicates success in achieving resource economy in the design of the course when compared to other estimates.

The design of the course website was done by the course director. Having no prior experience or formal training in the subject, additional time was dedicated to understanding and becoming proficient in developing the web content. A two-hour crash course in Web design by a colleague was sufficient for website development to begin. Content was added to the website as the instructors presented the material to resident students. By course completion, the website consisted of 1.62 GB of content.

Overall resource commitment to distance education was small. With the exception of an additional website all other resources came from internal assets. Under the USMA model, remote education is achievable in a relatively short time-frame, but the effectiveness of this model must also be examined. In order to assess the effectiveness of the course, student performance and perception were examined.

Student Population Comparison

The ME350 course was taught to two distinct groups of students, those at USMA (resident) and those studying abroad (remote). A comparison of the two populations show very comparable trends in time spent per lesson. Student performance on graded events shows conflicting trends. On individual homework problem sets remote students scored lower than their resident counterparts. On the major examinations and the final examination the remote students all performed significantly higher. Statistical analysis of final examination and course grades showed that the difference in performance was statistically insignificant. An assessment of overall course perception between the two groups showed an overall better perception of the educational experience by the remote students.

Because the course content used in both the resident and remote ME350 courses was fairly identical, the semester provided an opportunity to compare the time students spent on lesson preparation. The student time survey is shown in Figure 4 below.

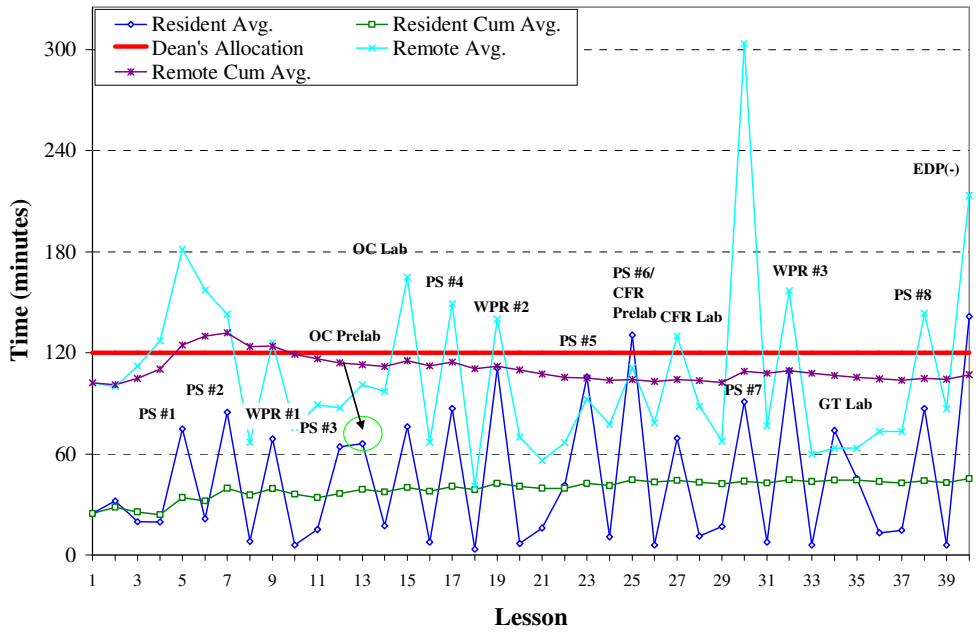
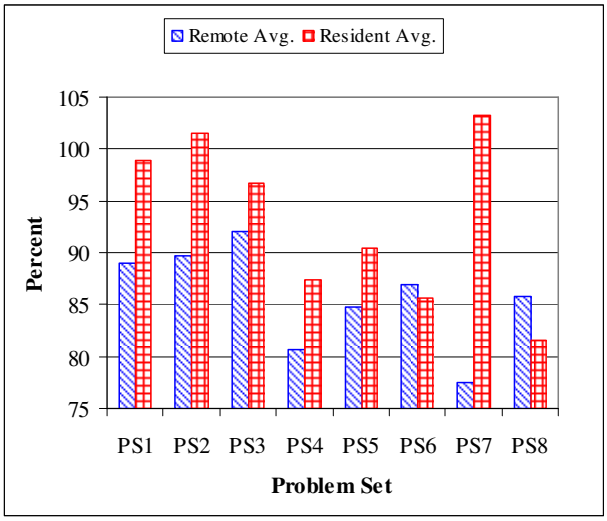


Figure 2. ME350 Student Time Survey for Academic Year 07-2.

Figure 2 shows the difference in average time spent per lesson as well as the cumulative average lesson preparation times for both the resident students and the remote students. The Dean's Allocation line shown signifies the time allocated in the students' daily schedule for a three credit hour course. For every hour in class the students should not spend more than two hours out of class (120 minutes as shown). It is interesting to note that the average difference between resident and remote student preparation time was 61.53 minutes. This demonstrates that the 55 minutes remote students do not spend in the classroom is about the same length of time they are spending in additional lesson preparation time. It is also interesting to note that the spikes in lesson preparation times correspond very closely to the dates of graded events throughout the course. The additional peak at lesson 5 for the remote education students is justified because this was the first lesson that three of the seven students spent at their remote locations (Russia). The additional spikes at lesson 30 and lesson 40 are explained at least partially by the students that fell behind throughout the semester. Two of the seven students remained within 2 lessons of the resident students throughout the semester. The remainder of the students averaged between five and 10 lessons behind their resident counterparts.

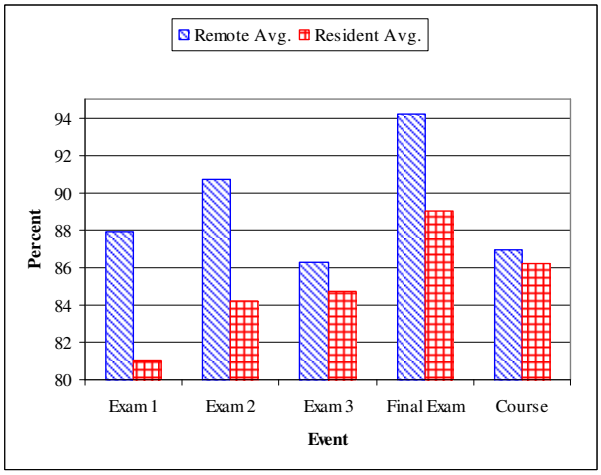
Although all students were initially encouraged to maintain the pace of the resident students, the difference in break schedules and remote student travel excursions prevented them from maintaining the resident pace. The instructors quickly embraced this dichotomy as "the cost of doing business". Overall, students appreciated the ability to work on flexible schedules, allowing them to better balance the demands of their host university program as well as those of ME350, which is consistent with findings from other courses[6]. The schedule differences for the remote students prevented continuity in instruction throughout the semester. When looking at overall student performance on graded events, this difference did not appear to have a significant impact on student performance.

Faculty compared graded event scores to gain a better understanding of group performance.



Event	Topic
PS#1	Cons. Of Mass/Momentum
PS#2	Ideal Gas Law, Energy Transfer
PS#3	Hydrostatics
PS#4	Pipe Flow
PS#5	Cons. Of Energy, Entropy
PS#6	Otto Cycle
PS#7	Regenerative Brayton Cycle
PS#8	Heat Transfer, Drag

Figure 3. ME350 Problem Set (PS) Performance Comparison.



Event	Topic
WPR#1	Cons. Of Mass/Mom./Energy
	Ideal Gas Law; Energy Transfer
WPR#2	Hydrostatics
	Pipe Flow
WPR#3	Cons. Of Energy, Entropy
	Otto, Diesel, Brayton Cycles

Figure 4. ME350 Examination Performance Comparison.

Figures 3 and 4 paint two different pictures of remote student performance compared to their resident counterparts. The remote students scored lower than their resident peers on all problem sets with the exception of sets PS6 and PS8. Students showed the opposite performance on examinations. This dichotomy can be explained in several ways. All problem sets with the exception of PS6 and PS8 included 5 point bonus questions. Typically, (presumably due to time constraints) remote students did not attempt the bonus questions, yet the vast majority of resident students did complete the bonus. Because the performance of the two groups is within five points it is arguable that the remote students may have performed better than their resident counterparts on the problems themselves. The remote students did not have the benefit of peer consultation while completing the problem sets. With the inability to openly discuss ideas regarding the completion of the assignments, remote students were forced to teach themselves the material, and may not have fully grasped the concepts during the conduct of the problem sets. The added benefit of this situation, however, may be a deeper level of comprehension for the

topics covered in the problem sets once feedback on the problem sets was received. This deeper comprehension may have manifested itself in the slightly higher examination scores for the remote students. The examinations given to the remote students were not remotely proctored. The examinations were identical to those given to the resident students. The remote students were encouraged to use only the authorized examination references (the text and a one page reference data card provided by the instructor) and to work within the same 55-minute time constraint imposed on the resident students to prepare for the final examination. Although they were encouraged to work under the same constraints, there was no way to monitor compliance.

A better indication of overall student learning comes in examination of student final examination performance. On average, the remote students scored 4% higher on the final than their resident counterparts. This examination was given under similar conditions and identical time constraints. Keeping in mind that four of the six students executed the final examination three to four weeks after the end of their semester (time spent conducting military training and travel unrelated to the course) it can be argued that the remote students gained a better depth of knowledge and greater retention. Overall performance in the course seemed to match results of other distance education experiences[7,8,9]. Earlier it was shown that the remote students had an average QPA almost 0.26 points higher than the course average. Depsite this large difference, the remote students had an overall course average 0.74% higher than their resident peers. This small difference in course percentages is a bit of a concern. Although they did perform slightly better than the course average, it seems that the rigors of remote education may have "leveled the playing field." A statistical analysis of both the final examination and final grade performance was conducted to determine whether the differences were statistically significant. This analysis proved inconclusive due to the small sample size.

In addition to an arguably better performance in the course, remote student perceptions of the course also seemed more positive. An examination of identical course end survey questions provides some insight into student perceptions.

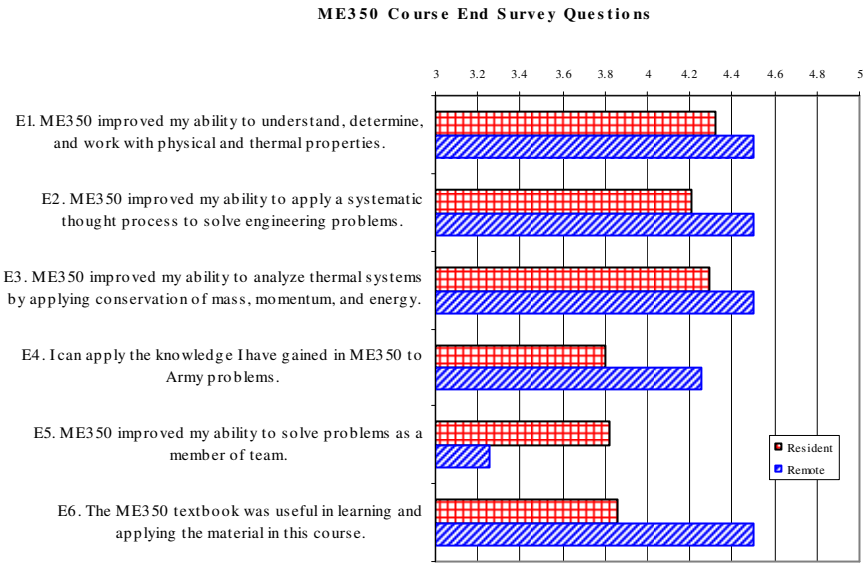


Figure 5. ME350 Course End Question Response Comparison.

Examination of the course end questionnaire responses shows a more positive overall perception of the course for the remote students. These questions (with the exception of E6) are taken directly from the ME350 Course Objectives. The most drastic contrasts come in the last two questions. For obvious reasons, the remote students did not work together in groups for any part of the course, while the resident students accomplished the lab demonstrations and the engineering design project in 3-4 person groups. The last question can be attributed to the increased need for the remote students to actually read the textbook in order to gain sufficient knowledge of the course subjects. Unfortunately, all too often instructors find that reading the text is the last resort for many undergraduate engineering students. Overall, despite accomplishing the same graded events, and referencing the same course materials, the remote students seem to have a more positive perception of the learning taking place throughout the semester. Again, this conclusion coincides with other experiences in Web-based education.[6,8,10]

Lessons Learned

Conducting ME350 via distance education provided some very useful insight into successful completion of remote education courses. Many of the major lessons learned are a direct result of the Internet connectivity available to the students overseas. Once all students arrived at their overseas locations, the instructors found a wide variety of Internet connectivity. The student studying in Egypt expressed to the instructors "problems connecting to the website". These same issues had already been addressed with the three students in Russia, so, the response was to find adequate Internet connectivity. This student never found adequate connection to the website from his host university, and relied heavily on second hand information from a "Battle Buddy" enrolled in the course at USMA. This student also conducted massive downloads of information whenever he traveled in the country, with Internet cafes and "western" hotels with business lounges being the preferred locations for connectivity. The full gravity of the connection issues was not relayed effectively to the instructors until the student's return to USMA for the final examination.

Based on this wide variety of Internet connectivity, time spent on the Internet per lesson varied. From focus group discussions it was determined that students with fast connections averaged between 10 to 20 minutes per lesson. Students with slower connections (particularly at Internet cafes) averaged between 45 minutes and 1 hour. Based on these estimates, it is expected that some students paid $80 to $100 of personal money in order to complete the course. Most students conducted course downloads simultaneously with personal correspondence to friends and family, so, for some the additional time burden was minimal.

Based on the experiences in ME350 gained throughout the semester, the following lessons learned have been forwarded to the USMA Center for Teaching Excellence and International Affairs Office:

1. Reliable high-speed Internet connectivity must be ensured for all students attempting a remote education experience. When this cannot be guaranteed at a remote location, wireless modem capability should accompany the student. (via cell phone or satellite cards)

2. All students should be issued portable scanners as a part of a remote education program. Scanners will alleviate the need to take digital photographs of written assignments for submission.
3. When possible, a remote education course should be given to students on CD, DVD, or memory stick rather than relying on the Internet for content dissemination.
4. The academy must develop an effective "Blackboard Like" Website for use in remote education. It must be outside the military domain and DOD firewall to ensure student access and help alleviate active blocking by foreign nations. This will eliminate the need to develop an entire course website from scratch every time a course must be taught via remote education.
5. All attempts must be made to identify remote education students as early as possible. Notifying the student of the need to take a course via remote education while already in the host nation is too late (although recoverable).
6. Allowing students to work self-paced is advantageous to the remote education experience. In some cases, adhering to the USMA lesson schedule is impracticable.
7. An acceptable live communicator server (e.g. AOL Instant Messenger) must be established in order to conduct additional instruction in "real time" as opposed to email.

Conclusions

The knowledge gained through the administration and analysis of the ME350 remote education course has provided new insights into the ability of CME to develop and implement remote education courses "on the fly". The digitization of course materials and the addition of only selected video clips proved adequate for six of seven non-major engineering students to receive a meaningful engineering education experience. Special care must be taken to ensure that students attempting a remote education experience are well prepared for the inherent rigors of remote education, especially when the remote course is outside of their "comfort zone". Student time commitment for the course was relatively consistent between the two formats when factoring in the time resident students spent in class. Overall student performance remained relatively consistent, with no statistical significance between the two groups in final examination and course total percentage. Remote students carried away a more positive attitude toward the learning accomplished in the course. The major drawback to the implementation of a remote education curriculum came in the faculty time invested in the course. The time required to sustain the remote education in addition to managing the resident enrolled students became an extreme burden. This scenario could not have been possible at a more research oriented institution where undergraduate education may not be the top priority. The faculty could not have managed a rigorous research agenda in addition to the teaching requirement.

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