AC 2011-522: DISTANCE EDUCATION PROGRAM IN ELECTRICAL ENGINEERING

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Distance Education Program in Electrical Engineering

Abstract

Traditional engineering programs are taught in a class setting, accompanied with laboratory exercises that complement lecture and reinforce theory. This is the ideal format, as students have easy access to both faculty and laboratories. Many times, however, students are place-bound in locations where they do not have access to institutions offering engineering programs. Furthermore, engineering degrees are expensive degrees and opening one requires a significant investment from the organization and/or the state. On the other hand, many community colleges have laboratories that are highly underutilized despite being adequate for undergraduate instruction. Following this reasoning Eastern Washington University (EWU) extended its established Electrical Engineering (EE) program into the Seattle metro area by partnering with North Seattle Community College (NSCC). Upon finishing their two-year degree at the community college, students start taking classes imparted by EWU faculty both through two-way interactive TV broadcasting and in the internet through Webex. This paper documents the various lessons learned through the first year of class delivery, including lecture delivery through TV broadcasting, dual-site laboratory management, advising issues, etc. Furthermore, it presents a model for a successful partnership between a four-year institution and a community college.

I. Introduction

For decades, engineering has been taught in an all too familiar method: Theory is imparted in a classroom and reinforced in a laboratory where either a faculty member or a graduate student assists students with their experiments. Student cohorts consists of a generally uniform group of students who have just finished high-school, live in dormitories or apartments close to lecture halls and have yet to have a taste of being part of the labor force. The few students not fitting that description are denominated "non-traditional," as they rarely amount to significant percentage of the student population. Many of these non-traditional students never even make it to a university not for lack of motivation, but for a variety of reasons. For example, they may be place-bound in locations where there are no engineering programs, or not have schedules flexible enough to accommodate the time intensive engineering classes, or simply the available programs have large class sizes leading to instruction that does not match their learning style.

One solution to this problem is to open more engineering programs wherever a need can be demonstrated to exist. This, however, is an impractical solution, as engineering programs are very expensive to set up and run, requiring not one, but several laboratories to match the needs of the various classes. For example, a typical electrical engineering curriculum has dedicated

laboratories for circuits, electronics, digital logic, power systems, microcontrollers, etc. While some of these can be combined into one laboratory (e.g. circuits and electronics), more commonly the variety of the equipment needed calls for several special-purpose labs which, in turn, need to be furnished, wired with proper emergency breakers, etc. The financial hurdle is only accentuated by the fact that engineering courses cannot exist in isolation, i.e. the degree requires a variety of supporting courses in Mathematics, Physics, Chemistry, English, etc. Additionally, a plethora of student services, such as financial aid, library material, bookstores, etc., should be made available.

Coincidentally, a system of community colleges exists in the country that typically provides all students services and teaches most supporting classes needed by engineering degrees. Many of these community colleges have laboratories used both for vocational and pre-engineering programs. These laboratories tend to be well equipped and grossly underutilized [1]. A logical conclusion, then, suggests itself: The resources available through the community college system must be coupled with those of four-year programs to offer engineering programs. The solution has three main advantages. First, universities offering 4-year engineering programs can reach a student population previously outside of their geographical scope without having to invest large amounts of money to set up laboratories and offer student services. Second, community colleges have a much more efficiently utilized set of laboratories and, thus, a much better return for the taxpayer's investment. Third, and most important, large numbers of students previously unable to attend an engineering program are provided with an opportunity.

The reasoning above, although providing a win-win situation to all constituents, requires a complicated process to be set up, as large entities are slow-reacting and, generally, try to avert radical changes. Navigating through the political maze can only be done if both organizations are completely sold on the idea. However, even once the administrative obstacles are overcome, we are still left with the biggest challenge of them all: Successful class delivery. Issues such as how to best present the material to the student, how are laboratories going to be done, grading, faculty availability, etc. still remain to be addressed. This paper documents the various lessons learned through the first year of the collaboration between Eastern Washington University (EWU) and North Seattle Community College (NSCC) to offer electrical engineering (EE) at the NSCC campus. Section II describes the extensive planning process carried by the two institutions, as well as the curriculum tailored for the non-traditional students expected to account for the majority of the student population. Administrative issues are addressed in section III, followed by classroom and laboratory issues in section IV. Finally, conclusions and closing remarks are presented in section V.

II. Collaborative Planning Between EWU and NSCC

The EE degree at EWU is housed by the Department of Engineering & Design (E&D). EWU is a midsized (i.e. ~10,000) regional comprehensive university located in the east side of the state. The EE program is accredited by the Accreditation Board for Engineering and Technology

(ABET) [2], and graduates about 15 students per year. A few years ago EWU was approached by the American Electronics Association (AeA) about filling a crucial need for electrical engineers on the west side of the State. The AeA was responding to an internal report generated by a task force from its state Council which advised that "state colleges and universities must increase capacity and improve access for would-be students" and that "the legislature should focus on funding new capacity in higher education." The only State university on the west side of the state offering an EE degree received state funding to increase capacity by 20%, but the need for more qualified graduating engineers remained unmet. The AeA had identified NSCC as a well suited community college partner for EWU, as its laboratories had been recently renovated to include state-of-the-art equipment for the pre-engineering and other technology-related programs. To put things in the correct geographical perspective, it is important to mention that EWU and NSCC are about 300 miles apart.

A team of faculty and administrators from both organizations immediately set to work to plan the new program based on the following mutually agreed tenets: provide state-of-the-art electrical engineering education methods, serve place-bound students, reduce costs for the tax payer, and serve underrepresented students. A summary of the team's decisions and its justifications are shown next.

i. *Provide state-of-the-art electrical engineering education methods*. Undergraduate engineering education in the United States has been the target of criticism for its very slow response to changes in the global economy. The bulk of the criticism centers around engineering programs not adapting to the skills that students will require when entering the workforce in a globalized economy [3][4][5]. Studies have shown that engineers in the 21st century will not work in isolation focusing only on the technical feasibility and implementation of a project, but instead will be part of large, interdisciplinary teams that are concerned with the technical specifications of a product, but also in its marketability and societal implications [6][7]. In short, engineers need to have increased communication skills and a much more entrepreneurial spirit. To address these issues, the EE program has an intense laboratory component in the curriculum, as *every* class is coupled with a laboratory. Labs are always team-based and, whenever possible, a "real-world" problem is assigned as a final project. The AeA involvement with the project ensured that a vast number of local and regional industrial partners were available from the very inception of the program, thereby simplifying the initial contact with local and regional industry. This aggressive solution intends to provide students with a much more seamless transition into the labor force, and to better prepare them for the changing engineering profession [8].

ii. *Serve place-bound students*. In an effort to fulfill the needs of both the industrial community and of those students bound to the west side of the state, classes are offered at NSCC. Data presented by NSCC and the AeA demonstrated that the pool of qualified students with interest in the program is older and unable to easily relocate for the purpose

of education. These students are typically on a second career, married to a place-bound spouse, or belong to ethnic groups where closeness to family is an essential value [9].

iii. *Reduce costs*. Cost reduction ws addressed from two perspectives: Cost to the tax payer and cost for the student. Financial savings for the state come in the form of more efficient utilization of laboratory and classroom facilities in NSCC. While the ideal scenario would be for laboratories at NSCC and EWU to be identical, efforts were made to ensure that laboratory content could be duplicated in both locations with only minor modifications.

Savings for the student were done in three main ways:

1. Ensuring students pay the cheaper community college rates for all lower division courses. EWU does not offer to students in this program any classes that NSCC already offers. Thus, NSCC students must take lower division courses directly from the community college system. A special memorandum of understanding was created accepting some classes listed as 300 level at EWU but offered as a 200-level course at NSCC, such as differential equations. For all of these courses, their content was thoroughly analyzed by faculty and no changes or additions were deemed necessary. As a result of this, only classes from the E&D Department need to be transmitted into the community college, minimizing the logistical effort that would have been required to coordinate with other departments, such as Math and Physics.
2. Generating a simplified set of requirements for admission into the program. NSCC is part of a larger community college system that has various campuses, all of which have a common class-numbering system. Faculty from both organizations met and determined a course-by-course one-to-one mapping for all lower division courses, resulting in class duplication being eliminated. As it stands, a student is accepted into the program once Physics III and Calculus III are successfully completed. At this point, students typically have obtained an Associate of Science degree, but this degree is not required for admission. Courses that have been successfully completed at NSCC do not have to be retaken from EWU.
3. Creating a curriculum that allows for timely program completion. A curriculum was created that ensures that students taking a full load can finish their programs within two years of entering it, given that all the lower division courses have already been completed. The curriculum is shown in Figure 1. Thus, students fully dedicated to the program will not have to stretch their curriculum beyond two years, at which point they can enter the labor force in full. Additionally, students can take classes at their own pace as they pay per course rather than for full-time (12-18 credits) or part-time (11 credits or less).

	Fall		**Winter**		**Spring**	
	Freshman					
	MATH& 151 Calc. I	5	*MATH& 152 Calc. II*	5	*MATH& 153 Calc. III*	5
	VLPA	5	*VLPA*	5	*VLPA or I&S*	5
	ENGL& 101	5	*ENGL& 102*	5	*CSC 142 Computer Programming*	5
45	Total	15	Total	15	Total	15
	Sophomore					
	I&S	5	*ENGL& 230 Technical Writing*	3	*I&S*	5
	PHYS& 221 Engr. Physics I	5	*PHYS& 222 Engr. Physics II*	5	*MATH 220 Linear Algebra*	5
	Math 224 Multivariable Calculus	5	*MATH 238 Differential Eq*	5	*PHYS& 223 Engr. Physics III*	5
43	Total	15	Total	13	Total	15
	Junior					
	CHEM 161 General Chem.	6	Signals and Systems I (ENGR 320)	5	Signals and Systems II (ENGR 321)	5
	Circuit Theory I (ENGR 209)	5	Microelectronics I (ENGR 330)	5	Microcontroller Systems (ENGR 260)	4
	or ENGR& 204 Electrical Circuits in prior Spring					
	Tech. and World Civil. (TECH 393)	4	Circuit Theory II (ENGR 210)	5	*Cultural/Gender Div.*	4
	Digital Circuits (ENGR160)	4	Digital Hardware (ENGR250)	2	Microelectronics II (ENGR 331)	5
54	Total	19	Total	17	Total	18
	Senior					
	Energy Systems (ENGR 350)	5	Stochastic Processes (Engr 383)	4	HDL (ENGR 360)	5
	Digital Signal Processing (ENGR 420)	5	Engr. Electromagnetics (ENGR 401)	5	Digital Communication (ENGR 440)	5
	CMOS Design (ENGR 430)	5	Approved Elective	5	Capstone (TECH 490)	4
					Approved Elective	5
48	Total	15	Total	14	Total	19
190						

Figure 1. Curriculum for EE program NSCC-based students. Note that the classes offered by the community college are indicated in italics.

iv. *Serve underrepresented students*. Building on the fact that 40% of NSCC's student population comes from diverse ethnic backgrounds, 58% are women, and most are older (average age 31) and place-bound, EWU's EE program is committed to tailoring instruction in a way that suits a variety of learning styles. For example, the program has left significant leeway for service learning components in the classroom, in the form of final projects or in the Senior Capstone class. Service learning typically engages students, faculty and community members in a community project. These types of projects allow students to become connected to the community and, thus, to provide a sense of civic engagement. Surveys have shown overwhelmingly that over 65% of students recognize civic engagement as a critical part of their education [10]. Research further indicates that women learn most effectively when theoretical concepts and classroom examples are clearly linked to real world situation. Additionally, it was been shown that female students excel in hands-on, collaborative educational settings [11][12]. Research further shows that minority students learn better when there is interaction between their experiences and their ideas [13]. More specifically, Hispanic students learn more effectively in collaborative environments that encourage team-based projects [14]. Thus, the experience-based model used in the program, with a lab-intensive curriculum that emphasizes real-world projects, we are serving minority students in engineering.

III. Administrative Issues

As mentioned in the previous section, a dedicated team of faculty and administrators from both institutions worked together to plan the program. This team included three faculty from each institution, the Associate Dean of the College of Science, Health and Engineering from EWU and the Dean of the College of Math, Science, and Social Sciences from NSCC. However, talks were initiated by a meeting led by the presidents of both institutions, as it was clear from the incipient stages that successful negotiations would be successful only if the highest authorities from EWU and NSCC were sold on the project. While the faculty agreed on the class-related issues, administrators dealt with the memorandum of understanding (MOU) that binds the two parties in a yearly agreement. Selected items in the MOU are described with more detail next.

Memorandum of Understanding

The MOU [15] is a covenant between EWU and NSCC that articulates that both institutions agree, among other things, to the following (MOU language in italics):

- *NSCC graduates who hold Direct Transfer Agreement associate degrees may enroll in this B.S. degree program without leaving their home campus.* This is in direct agreement

with the request of the AeA to generate more qualified electrical engineers in the west side of the state and, at the same time, serve underrepresented, non-traditional students who may be place-bound.

- *EWU recognizes the advantages of joint promotion projects to inform the community about higher education options on the NSCC campus, and seeks opportunities to participate in those efforts*. The burden of recruitment lies within both institutions. While a large part of the students entering this program come from NSCC, there are three community colleges in the Seattle community college system, which serve over 54,000 students. Thus, EWU has stepped up recruitment efforts in the area. The first cohort (i.e. the first junior class) consisted only of 6 students, but the second, with the increased recruitment efforts by both institutions stepped up to 18 students.

- *A minimum of 60 credits at the upper-division level will be required to complete the Bachelor of Science in Electrical Engineering degree. It is expected that [the number full time equivalent students will be maintained at] a minimum of 15 active student enrollments.* While EWU recognizes that this is an important effort, the resources of the State and University are limited. Thus, the program is "self support," which implies that there is no state subvention for student tuition. The break-even point for EWU lies at about 14.5 full-time equivalent students. EWU recognizes that this is a steady-state condition and, thus, is willing to accrue some loss in the first years of the program.

- *The Presidents of Eastern Washington University and North Seattle Community College, or their designees, shall be responsible for the administration of this Agreement. This Agreement shall be reviewed at the completion of each academic year by the appropriate representatives of North Seattle Community College and Eastern Washington University and amendments may be required to maintain an equitable relationship between the two institutions*. This demonstrates the recognition of the need to maintain the highest spheres of administration involved in the program. While collaborative exercises of this nature are always well intentioned, it is not uncommon for them to fail due to political friction between institutions.

- *This Agreement may be terminated or amended by mutual agreement and/or upon no less than 90 days written notice by one party to the other. […] The program will terminate after the last cohort has had sufficient time to complete the required coursework*. A built-in safeguard for students, so that if the program is terminated, students already in the program will be provided with the necessary conditions for them to complete their degrees.

The obligations of each institution are also clearly spelled out in the MOU. They are separated into EWU's and NSCC's as follows:

North Seattle Community College's agrees to provide administrative support as follows:

- Office space for EWU faculty (and staff if necessary) equivalent to the quality of space provided for NSCC personnel.
- Use of NSCC staff and faculty lounges by EWU staff/faculty offered at the same level as that enjoyed by NSCC staff and faculty.
- Conference rooms and special facilities made available for occasional use when the college determines that the space is available.
- Utilities including heat, lights and custodial services provided at the same level and frequency as other NSCC offices and classrooms. EWU offices will comply, operational needs permitting, with NSCC's Energy Conservation policies.
- Mail Services (outgoing and incoming) provided at the same level as for NSCC offices. EWU will reimburse NSCC for postage at cost.
- Transportation and Parking services for EWU faculty, staff, students and visitors provided at the same level and rates as those of NSCC personnel. Persons utilizing these services will be individually responsible for fees associated with this use.
- Use of NSCC's cafeteria/food services by EWU staff, faculty, students and visitors offered at the same level and rates as those enjoyed by NSCC's personnel.
- Library Support Services offered at the same level as that enjoyed by NSCC staff and faculty.
- Technology Support Services offered at the same level as that enjoyed by NSCC staff and faculty.
- Student Support Services offered at the same level as that enjoyed by NSCC students.

Eastern Washington University agrees to provide support as follows:

- The responsibility for hiring faculty. Any faculty travel costs will be the responsibility of EWU.
- If EWU's occupancy of the classroom space should cause NSCC to incur additional direct costs (i.e., utilities, custodial, security), EWU will reimburse NSCC for those costs.
- EWU will be responsible for registering students and posting student grades by the deadlines established by EWU.

Inasmuch as NSCC is expected to provide office and classroom space and support for the program, EWU reimburses NSCC as detailed below (rates are agreed upon yearly by both institutions):

- For all general support services provided under this agreement, EWU agrees to pay to NSCC starting for: classrooms and office space sufficient to support the program, local telephone service, FAX analog telephone line, key requests, office technology support, audio-visual classroom support, mail service, parking, computer lab usage, wellness center usage, special accommodations for students, student IDs.
- Conference rooms, classrooms, and special facilities for occasional non-program related uses will be rented according to the NSCC room rental schedule.

- For direct, variable operating costs e.g. postage and copy-duplicating, EWU will reimburse on a quarterly basis when invoiced by NSCC.

As expected between any agreement where lawyers are involved, language regarding liability is included to make each institution "responsible for damages to persons or property resulting from the negligent acts or omissions on the part of itself, its employees, or its officers." [15] Additionally, neither EWU nor NSCC "assumes any responsibility to the other party for the consequences of any act or omission of any person, firm, or corporation not a party to this agreement." [15]

First Year Results

The MOU in [15] has been successful in ensuring that the first year of the program in the west side was not plagued with administrative hurdles. A faculty from EWU taught full time in NSCC and was provided with an office, internet access, office support, and access to all pertinent laboratories. The staff and faculty of NSCC were always a good resource when simple things ranging from where the key shop is to what help is available in the college for students with psychological problems. One issue that did come up is the lack of initial communication of the MOU to secretarial staff. Once the MOU was thoroughly disseminated, it became a lot easier to make copies of assignments, mail exams to the main campus, etc.

IV. Academic-Related Issues

The initial stages of the project involved studying other university/community college collaborations (e.g. [16][17][18]), and the faculty spent a significant portion in the design stage looking at the elements that caused both success and failure at the different ventures. From this study, the following recommendations were implemented.

- *Classes must be live, two-way interactive*. The State's K-20 system already in place was tapped to offer classes that are two-way interactive, i.e. the student in the remote location has access not only to audio and video of the instructor (and his/her writing and/or PPT presentations), but can participate in the classroom simply by turning on a microphone on the remote locations. All student desks are equipped with a control that allows the mic to be either on or off. Note that classes are taught for both the NSCC and EWU cohorts at the same time.
- *Laboratories must be done on-site and should be supervised by a faculty member.* Although students could perform laboratories on their own, especially if instruction handouts are very detailed, students can become frustrated by not being able to complete assignments in a timely manner due to lack of access to an instructor. Thus, a full-time faculty from EWU has relocated to Seattle to serve as the lab instructor.

- *All course material must be made available to students.* Although the K-20 system is used for transmitting video, audio, and any documents read by a docu-cam, lecture is typically by writing class notes in a tablet PC and transmitting it through Webex, a real-time desktop sharing package. Note that it is also possible to transmit audio through Webex. This allows students not able to make it to class due to work reasons to view class notes and listen to audio in real time. All material is made available to students via the course's website or Blackboard [20], the course management system at EWU.
- *Fast document delivery between EWU and NSCC campuses.* Most communication is done electronically either through email or Blackboard. However, there are many cases where hard copies of documents must be made available to and from either side. Exams, for example, must be quickly delivered to the faculty teaching the class for fast turnaround time of graded work. For these cases, the EWU uses next day delivery through UPS. Students have not voiced concerns about this solution.

First Year Comments

A good measure of student satisfaction is the 300% increase of student cohorts from 1st to 2nd years. The 2009-2010 Junior class (all students start as Juniors) had 6 students, the 2010-2011 Junior class has 18 students. Although a fair amount of this is due to the increased recruitment done by EWU in the west side, it is reasonable to assume that word of mouth also played a role. Students are very motivated and, in fact, the top student of the Junior 2009-2010 class came from the remote site.

Class-delivery technology has been very easy to learn, once the tablet is turned on, a few clicks on the touch-screen control panel gets the class going. However, a few glitches had to be smoothed out along the way. For example, microphone levels in the EWU site had to be tuned carefully for the sound of students turning a page in their notebooks not to become a distraction to the remote location. Class was disrupted a couple of times by loss of connection, due to a hard to detect loose connection, etc. A survey of students, however, showed unexpected patience with the technological glitches. The shift from receiving instruction on the whiteboard to watching it in a screen, however, proved to be distracting for students at the EWU site. Note that the same notes transmitted through Webex to the remote site are put on a screen in the classroom. However, just as faculty adapted their teaching style to using a stylus and a tablet, it is apparent that students adapt their learning styles to the new deliver method after only a few days.

Students at the NSCC site have expressed satisfaction about having an instructor available to provide help during labs and to be the on-site advisor. The increased student-faculty interaction led to a very convivial relationship among both parties, thereby creating a great environment for student learning. It has to be said that one faculty member teaching all labs can lead to a high burnout rate. Note, however, that faculty from the NSCC site can (and do) teach classes that are beamed to the EWU site, thus making EWU the remote site. In the future, as the NSCC cohorts become larger (and more faculty are hired), it will be desirable to increase the number of classes

taught from NSCC or, for that matter, duplicate classes so that they are taught independently in both sites.

Although students have on-site help, they are encouraged to seek help from the class-instructur either through email or by phone. This has led to a much larger amount of time dedicated to electronic communication that with a normal, on-site only class. The university has provided financial compensation to account for this. It is worth noting that faculty do travel to NSCC at least once per term to provide further one-on-one help to students.

V. Conclusions

This paper has documented the dual-site distance education program in electrical engineering done through the collaboration between EWU and NSCC. The program, taught through a combination of two-way interactive lectures and on-site laboratory sessions, has a healthy enrollment. The program was implemented after careful planning done by a team of faculty and administrators from both institutions. Technology has proven to be a neutral player in class delivery, not a negative one as was initially expected. Collaborations between four-year institutions and community colleges are beneficial to the state as it better utilizes laboratories and classrooms which may have not been used to capacity before. It is possible that dual-site programs are going to become more common as we couple financial problems with the need for more qualified graduating engineers. Should that happen, we believe that the model adopted by EWU and NSCC can be duplicated by other institutions.

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