AC 2012-5049: USEFUL STRATEGIES FOR IMPLEMENTING AN ON-LINE UNDERGRADUATE ELECTRICAL ENGINEERING PROGRAM

Dr. Craig J. Scott, Morgan State University

Craig Scott is a professor and Chairperson for the Department of Electrical and Computer Engineering at Morgan State University, Baltimore, Md. He is currently directing research in developing tools for visual analytics, image/spatial data fusion, and aircraft synthetic vision systems. Additionally, he is conducting pedagogical studies on learning technologies and remedial math preparation for engineering students. He instructs courses in electromagnetics, solid state theory, characterization of semiconductor materials, computer vision, and computational electrical engineering.

Dr. Petronella A. James, Morgan State University
Dr. Yacob Astatke, Morgan State University

Yacob Astatke completed both his doctorate of engineering and B.S.E.E. degrees from Morgan State University (MSU) and his M.S.E.E. from Johns Hopkins University. He has been a full-time faculty member in the Electrical and Computer Engineering (ECE) Department at MSU since Aug. 1994 and currently serves as the Associate Chair for Undergraduate Studies. He teaches courses in both analog and digital electronic circuit design and instrumentation. Astatke has more than 10 years' experience in the development and delivery of synchronous and asynchronous web-based ECE courses in the USA and abroad. He is the recipient of the 2012 ASEE Mid-Atlantic Section's Distinguished Teaching Award.

Dr. Jumoke O. Ladeji-Osias, Morgan State University

Useful Strategies for Implementing an Online Undergraduate Electrical Engineering Program

Abstract

Online programs in Electrical Engineering disciplines have been mainly offered at the graduate school level to avoid the complexities associated with conducting courses that require a laboratory component. To our knowledge, there are only a handful of online Accreditation Board for Engineering and Technology (ABET) undergraduate programs offered nationwide that require students to conduct laboratory sessions onsite. For some students this arrangement may be inconvenient, or in some cases, impractical. Furthermore, there are many challenges associated with teaching electrical engineering online courses because of the interposition of heavy equation use and interactivity required.

Over the past three years, we have been investigating the use of inexpensive, highly portable instrumentation to facilitate our lab requirements. As a result of this enabling technology, an online program targeted toward completing the second two years of an undergraduate electrical engineering degree is being piloted at our institution. Nearly 109 students have participated in this study. A two-plus-two approach avoids the need for an institution wide conversion of all required courses. Among other findings from a survey taken, the most salient issue facing faculty course builders was the extraordinary time commitment needed to complete course certification. On the other hand, this teaching option has great appeal to working professionals in that it affords a greater degree of flexibility by not having to meet and commute at scheduled times during the course of a week. The impact on the rate at which students matriculated has been encouraging. Students are able to complete more courses over the summer resulting in synchronizing larger cohorts of upper-class students. Special care must be taken, however, to assess a student's ability to work independently and to assess whether or not they have reasonable expectations of the degree of time management and persistence needed to satisfactorily complete their coursework online.

In this paper, we detail the curriculum changes, how the formats of both laboratory and non-laboratory courses were modified, the process of recruiting and certifying faculty to teach these courses, and the evaluations of student perceptions while participating in these courses. As a result of this pilot study we can conclude that conducting a fully online undergraduate Electrical Engineering program appears to be viable and that these efforts may help to lead the way in establishing this discipline as a competitive online undergraduate program alternative.

Introduction

With the rapid evolution of communication and computer technologies, the number of online engineering programs has also grown substantially. Graduate online engineering programs have become more and more plentiful as compared to undergraduate programs owing to the suitability of the target audience in terms of accessibility and flexibility, and maturity. The online student is typically a lifelong learner, more concerned with commuting and non-academic responsibilities, and motivated to complete assignments individually.[1] Moreover, graduate courses are more content and design centered with less needs for laboratory experiences.[2] Undergraduate programs are considerably less available owing to a significant laboratory experience requirement. At present, there is only one online ABET accredited Electrical Engineering program offered nationwide. [3] In this program, students are required to conduct the laboratory exercises on campus. More recently, we have been successful in developing and teaching completely online electrical engineering courses with laboratory components. [4] While our primary motivation is to provide a quality education to those who would not otherwise be in a position to pursue one, reaching out to students that inhabit areas with little post secondary infrastructure has meritorious implications. This reasoning can be extended not only nationally but also to restricted global communities.

In this paper, we discuss our experiences in implementing the upper-division portion of an electrical engineering program designed to complement the needs of a student acquiring an Associate degree in this area. A common trend for many students is to accomplish General Education requirements at a community college. If available, some lower-division courses may also be taken at a two-year institution. The availability of low cost portable instrumentation allows us to offer the last portion of our program fully online.

Curriculum and Course Design

The primary reasons for delivering undergraduate courses and programs online are to allow our campus to expand enrollment beyond the limitations of available classroom space, and to reach student learners that would not otherwise come to campus. One salient need and opportunity for undergraduate online education is to offer concurrent sections of core undergraduate courses so that students have more varied access to these courses. Morgan State University is in the process of expanding in liberal arts and the general sciences a number of such courses in the College of Arts and Sciences but it may be some time before all the General Education and University requirements are offered fully online. This is where the synergy between two-year and four-year institutions can be leveraged to minimize cost and duplication associated with bringing up a fully online program. Likewise, negative experiences with lower-division undergraduate students having poor success rates in online courses can be abated owing to the experience gained in pursuing general studies at a two-year institution.

Table 1: Two-Plus-Two Online Program Course Sequence

STUDENTS COMPLETE 1^{st}& 2^{nd} YEAR of ECE PROGRAM AT COMMUNITY COLLEGE OR 4-YEAR INSTITUTION					
FIRST YEAR – (FIRST SEMESTER)			**FIRST YEAR - (SECOND SEMESTER)**		
CHEM 110	Gen. Chem + Lab (for Engineers & Scientist) **	5(TR)	PHYS 205	Physics I + Lab (for Engineers & Scientist) **	5(TR)
MATH 241	Calculus I	4(TR)	MATH 242	Calculus II	4(TR)
ENGL 101	Freshman Comp I	3(TR)	ENGL 102	Freshman Composition II	3(TR)
HIST 101/105	History I	3(TR)	HIST 102/106	History II	3(TR)
ORIE 104	Intro To Engineering I	1(TR)	EEGR 105	Intro To Electrical Engineering*	3(TR)
PHEC XXX	Physical Ed	1(TR)			
		17 (TR=17)			**18 (TR=18)**
SECOND YEAR – (FIRST SEMESTER)			**SECOND YEAR – (SECOND SEMESTER)**		
PHYS 206	Phys II + Lab (for Engineers & Scientist) **	5(TR)	MATH 243	Calculus III	4(TR)
MATH 340	Diff Equations	3(TR)	EEGR 221	Signals & Systems *	4(TR)
EEGR 202	Electrical Circuits **	4(TR)	EEGR 211	Intro To Digital Logic *	3(TR)
EEGR 203	Intro To EELab **	1(TR)	ECON 211	Economics (Macro)	3(TR)
EEGR 161	Object Orient Programing	3(TR)	HUMA 201	Intro To Humanities I	3(TR)
HEED 100	Health Education	2(TR)			
		18 (TR=18)			**17 (TR=17)**
				TOTAL TRANSFER CREDITS	**70(TR)**
STUDENTS COMPLETE 3^{RD}& 4^{TH} YEAR OF ECE PROGRAM AT MORGAN STATE UNIVERSITY					
THIRD YEAR – (FIRST SEMESTER)			**THIRD YEAR – (SECOND SEMESTER)**		
EEGR 215	Electronic Mat & Dev	4	*EEGR 317*	*Electronic Circuits*	*4*
EEGR 305	*Electromagnetics*	*4*	*MATH 331*	*Applied Prob & Stat*	*3*
EEGR 322	*Discrete Systems*	*3*	*IEGR 305*	*Thermodynamics*	*3*
APPR XXX	*Approved Elective/EEGR243*	*3*	*EEGR 4XX*	*ECE Elective****	*3*
HUMA 202	*Intro To Humanities II*	*3*	*BIOL 101*	*Biology*	*4*
		17			**17**
FOURTH YEAR- (FIRST SEMESTER)			**FOURTH YEAR - (SECOND SEMESTER)**		
EEGR 390	*Principles of Design*	*2*			
EEGR 400	*Intro To Professional Practice*	*1*	*EEGR 491*	*Sr. Design Project II*	*2*
EEGR 490	*Sr. Design Project I*	*1*	*EEGR4XX*	*ECE Elective ****	*3*
EEGR 4XX	*ECE Elective****	*3*	*EEGR 4XX*	*ECE Elective****	*3*
HIST 350	*Intro To Black Diaspora*	*3*	*PHIL 109*	*Intro to Logic*	*3*
CEGR 304	*Engineering Mechanics*	*4*	*HUMA XXX*	*Humanities Elective*	*3*
		14			**14**
				TOTAL CREDIT HOURS	**132 (133)**

A plus-two curriculum sequence is conceived in light of the State of Maryland Associate of Engineering degree offered by many community colleges statewide. Several community colleges are equipped to offer Calculus based introductory electrical engineering courses to ensure an easy transition to four-year institutions. The current plus-two program requires 65 credits of courses, consisting of 18 credits of lab augmented core courses, 15 credits of non-lab based core courses, 12 of 21 credits of elective courses, and 20 credits of non-electrical courses. A model program is shown in Table 1.

The salient features of this curriculum design are that it:

- Is the only accredited electrical engineering program that allows completion of all laboratory courses online.
- Allows students an opportunity to obtain a BSEE in electrical engineering by completing the third & fourth year at Morgan State University.
- Is designed for graduates of the associate degree in electrical engineering from another university or community college.
- Allows students to complete the ECE curriculum part-time or full-time, online or face-to-face, or in any combination thereof
- Requires students to maintain a 2.0 cumulative grade point average in order to transfer at the 56-credit level or higher
- Allows a maximum of seventy (70) credit hours from a community college or 4-year institution towards fulfillment of the minimum one hundred thirty-three (133) credit hours required for baccalaureate completion.

All courses offered within this program require certification using the “Quality Matters (QM)” standard rubrics.[5,6] This rubric outlines many of the practices that are generally accepted for teaching engineering courses and includes some items that are critical for an online student’s success. In addition, any online instructor must also receive certification either as a builder or online teacher using a similar rubric for evaluation. This effort was sustained over a two year period following a strategy of completing the most challenging core laboratory courses and then turning our attention to building the core non-laboratory courses. Near the end of the building phase the elective courses and non-electrical engineering courses were considered.

Laboratory Based Core Course Curriculum and Content Design

In the earliest phase, all needed hardware and software components, such as whiteboards, lecture capture software and upgrades of existing tablet computers were procured and updated by the project manager. Laboratory space was reconfigured to allow lecture capture and access for building the courses. Systems tests were run to ensure that all requirements were met, as well as, to document policy and procedures for system use. Eight major meetings were held in conjunction with the ECE Department curriculum review committee, resulting in the laboratory courses shown in Table 2 being approved for online delivery.

Table 2: Laboratory Courses

BUILT	COURSE DESCRIPTION	CREDITS	STATUS
6 LAB (CORE) COURSES - 18 credit hours			
Spring/Fall 2010	EEGR202 Electric Circuits	4	Certified
	EEGR203 Introduction to Electrical Laboratory	1	Certified
	EEGR211 Introduction to Digital Logic	3	Certified
	EEGR215 Electronic Materials and Devices	4	Certified
	EEGR317 Electronic Circuits	4	Certified
	EEGR390 Principles of Design	2	Certified

The course rubrics being used were found to be commensurate with the planned online offerings because they are directed at measuring the achievement of program goals which are overarching. New task level rubrics were needed to guide online discussions and participation.

As a result, methods to use Adobe Connect™ for remote lab demonstration[7] were conceived and tested. All of the laboratory classes require demonstrations by the students which was a major concern at the beginning of this project. Sharing live video and simulations via remote desktop proved to be an innovative solution to dispel any concerns. Course developers were instructed on how to use the system for lecture capture and storage on Blackboard™ and using Adobe Connect™ for collaborating. Instructors received training on building and delivering online courses using Blackboard. Mobile studio boards were distributed to builders and instructors. For courses with laboratory components, the course developers were required to train on the use of the Mobile Studio™ technology[8].

Non-Laboratory Based Core and Elective Course Curriculum and Content Design

During this phase, six core non-laboratory courses (15 credits) were built and modified to meet the quality rubrics for online/distance learning. Of the twelve ECE electives, seven were built and modified (21 credits), in addition to two non-ECE electives (7 credits). The non-laboratory core courses and elective courses are shown in Tables 3 and Table 4 respectively. To date a total of 60 credit hours of both laboratory and non-laboratory courses and electives have been built and modified, with 54 credit hours of upper-level courses being certified to the "Quality Matters (QM)" standard rubrics.

Table 3: Core Courses

BUILT	COURSE DESCRIPTION	CREDITS	STATUS
6 CORE COURSES 15 credit hours			
Spring/Summer 2011	EEGR221 Signals and Systems	4	Certified
	EEGR305 Electromagnetics Theory & Applications	4	Certified
	EEGR322 Discrete Systems	3	Certified
	EEGR400 Introduction to Professional Practice	1	Certified
	EEGR490 Senior Design Project I	1	Certified
	EEGR491 Senior Design Project II	2	Certified

Table 4: Electives and Non-ECE Courses

BUILT	COURSE DESCRIPTION	CREDITS	STATUS
9 ELECTIVES REQUIRED - ECE 12 CR/Non-ECE 20CR			
Summer/Fall 2011	EEGR409 C Language Applications	3	Certified
	EEGR417 Microcomputer Design	3	Certified
	EEGR424 Power Systems Analysis	3	Pending
	EEGR451 Digital Signal Processing	3	Certified
	EEGR453 Communications Theory	3	Certified
	EEGR463 Digital Electronics	3	Certified
	EEGR475 Computer Vision	3	Certified
	CEGR304 Engineering Mechanics	4	Certified
	IEGR305 Thermodynamics	3	Pending

Unique Faculty Challenges

One of the difficulties in providing an online engineering curriculum is the lack of certified instructors available to build and deliver online engineering courses. Best practices show that the most effective way to build courses is by having experienced course builders work together with faculty to develop online course content. However, in many cases the infrastructure may not be in place for newly developing programs. Our institution is in the process of building the necessary infrastructure, so an alternative method was devised to motivate faculty to build and teach an online course. Considerable effort was made in aggressively recruiting, training and certifying both full time and adjunct faculty to build a readily available resource base. It was decided that adjunct course builders will work in consultation with experienced faculty members. Institutional and external funding support was required to finance the building and pilot testing of all courses needed. Completion of the pilot study would be difficult in the absence of this type of support.

Challenges with technology and support

Throughout all stages of the online program development, faculty and course builders received training on building and delivering online courses using the available technology. Major hardware components such as white boards, Panopto Focus™ and tablet computers were used to build supplemental lecture material. A special laboratory space was reconfigured to allow lecture capture and access for building the courses. Ultimately, supplying each builder and instructor with a tablet PC to capture lecture notes and amend their notes in a private setting created more flexibility and quicker response time. It was also determined that a dedicated person is needed to install and maintain all hardware and software associated with delivering course content.

Course Building and Certification

The certification rate for faculty and adjuncts averaged 67%, with 22 instructors completing certification during the 3-year online program initiation and piloting phase (Table 5). Sixteen (16) instructors completed the 9-week online course design (OCD) module, and six (6) completed the 7-week teach online (TO) certification. Instructors who successfully completed the OCD module were certified for both course design and teaching online.

Table 5: Total Instructor Certification

INSTRUCTOR	OCD	TO	TOTAL	Rate
Faculty (11)	4	3	7	64%
Adjunct (22)	12	3	15	68%
TOTAL	16	6	22	67%

As stated earlier, all instructors who were expected to interface with the online program were required to complete *QM* certification for online course building or teach online. This required in most instances that instructors commence and complete these certification requirements during the instructional phase of a semester. This was not only challenging and demanding for the instructors, but contributed in large measure to an extended building phase for the scheduled courses. Instructors' feedback was mostly centered on the time constraints to develop and build aligned content, time constraints to research and locate all the available materials and resources, conversion of face-to-face lecture notes for online format, and developing course content while engaged in industry full-time. Comments from instructors who were involved in the design/build phase of the courses were both instructive and insightful.

Course Delivery and Support

During the course test and evaluation the effectiveness of the modified curriculum was periodically assessed using surveys, interviews, and course outcomes. Subsequently, the remaining courses were offered and the evaluation information gathered to serve as a basis for continual improvement and the development of best practices. During this development phase, over 103 seats were occupied. In most cases for a course pilot rollout, the initial modality was face-to-face followed by a gradual transition to a fully online format. This allows a new online instructor to adapt to the different modalities of online pedagogy and also gives the student time to adapt. Surveys and information sessions were held to ascertain the effectiveness of the course design and the instructional technologies.

The results (n=48) show for sixty eight percent (68%) of the respondents this was their first online course. Seventy nine (79%) were full time students and ninety four percent (94%) lived within a 50 mile radius. The overall satisfaction with the instructor is fairly good. A comparison showing positive (strongly agree and agree) of five-level Likert responses for the laboratory versus non-laboratory courses is shown in Figure 1 below.

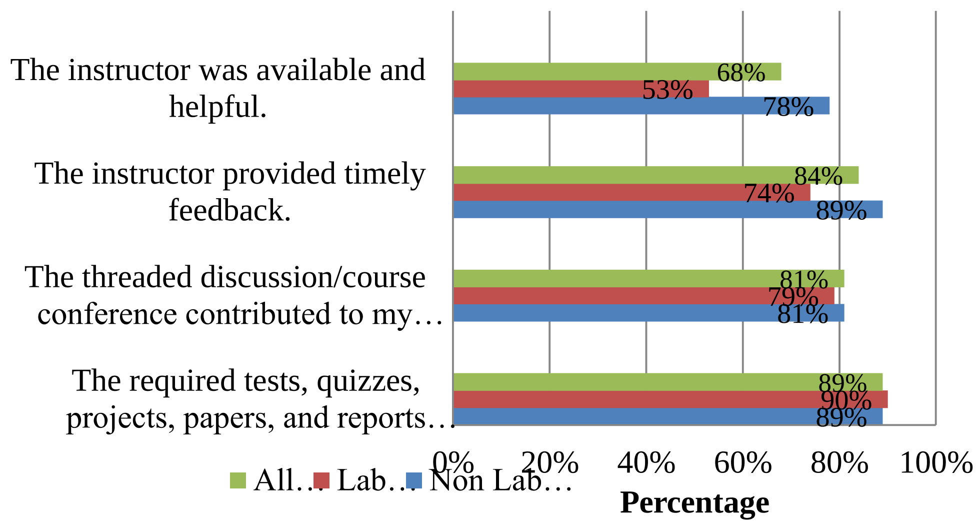

Figure 1: General course evaluation results

For most aspects, the student's perception is slightly lower for the laboratory based classes as compared to the non-laboratory based courses. There appears to be a noticeable difference for availability, feedback and helpfulness indicators. Upon examination of the qualitative responses, there appeared to be some frustration at the onset of the class owing to a quick ramp-up on the use of the Mobile Studio boards and the transition from conventional laboratory equipment. Although these skills were eventually mastered, the students felt as though they needed more time from the instructor to help. Developing better pre-course tutorials on using this technology should address this problem.

Student impressions of the helpfulness of key instructional technologies such as white boarding, Mobile Studio™, and lecture capture are important indicators of their effectiveness. Again, it is noted that the laboratory based courses have slightly lower agreement levels as compared to those who are not in the laboratory environment (see Figure 2). Most importantly the qualitative results indicate this depression is due to the availability and not the utility of the tool when considering the whiteboard and lecture capture. Students indicate a strong preference for video recordings and would like to see more. In light of the short comings of not having enough ramp-up time for familiarizing the student with the Mobile Studio boards, there is still a very positive perception that this lab approach is helping them conceptualize measurement techniques and understand theoretical concepts better.

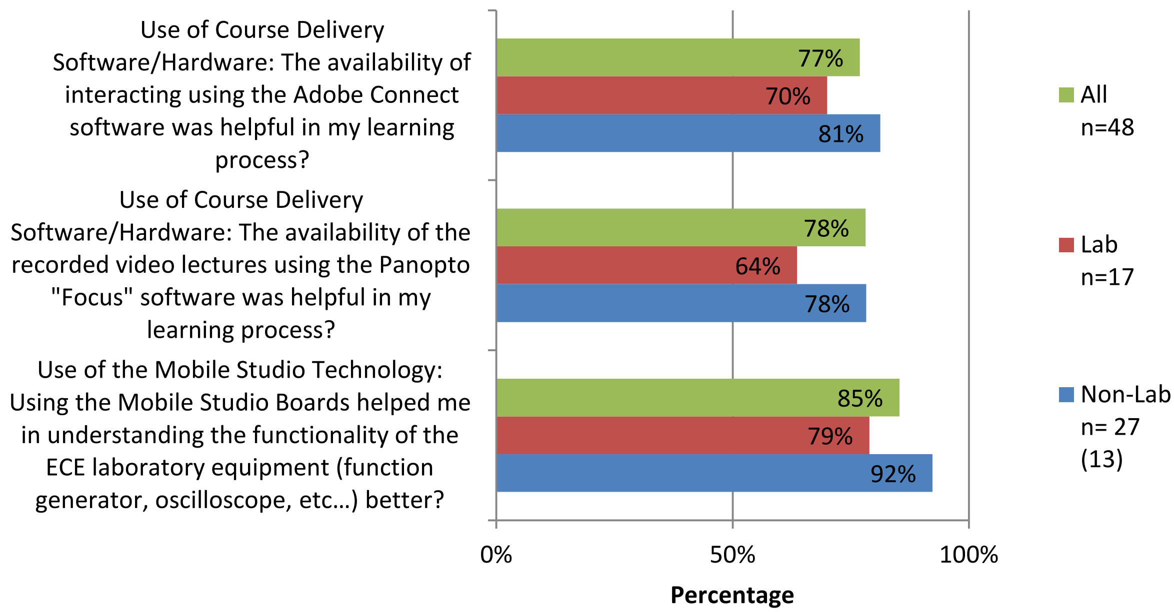

Figure 2: Comparison of various online instructional technologies

For the first time in the history of our program, summer courses were offered and met with great enthusiasm by our students. In particular, the EEGR 317 Electronic Circuits course saw an enrollment of 16 additional students during the summer of 2011. The EEGR 490 Senior Design Project I course is a graduation predictor for the Spring of 2012 and the EEGR 317 course is a core prerequisite for the first part of the capstone design course. The enrollment history for both EEGR317 and EEGR490 courses are shown in Figure 3.

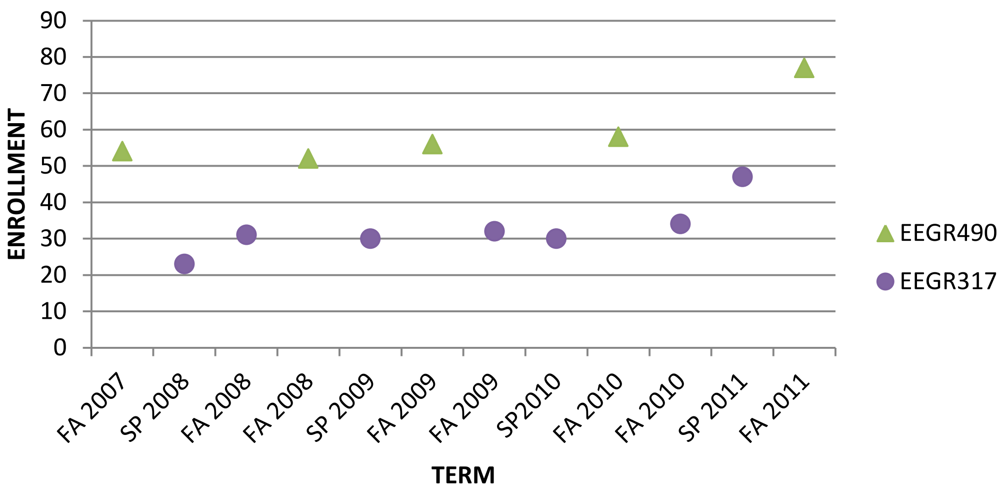

Figure 3: Enrollment history for Electric Circuits and the Senior Capstone courses.

The increased enrollment in these courses is expected to result in the predicted graduation class size owing to the availability of summer courses to allow students to catch up. At present, students seeking to enroll in an online section must have a cumulative GPA of at least a 2.0. This policy is a minimal attempt to identify those students that may not possess the proper study skills or self-efficacy traits, needed to master an online course offering. Figure 4 depicts the average of the final course grades received by all the online courses and the complementing non-web based sections. The average scores are notably higher for the online sections.

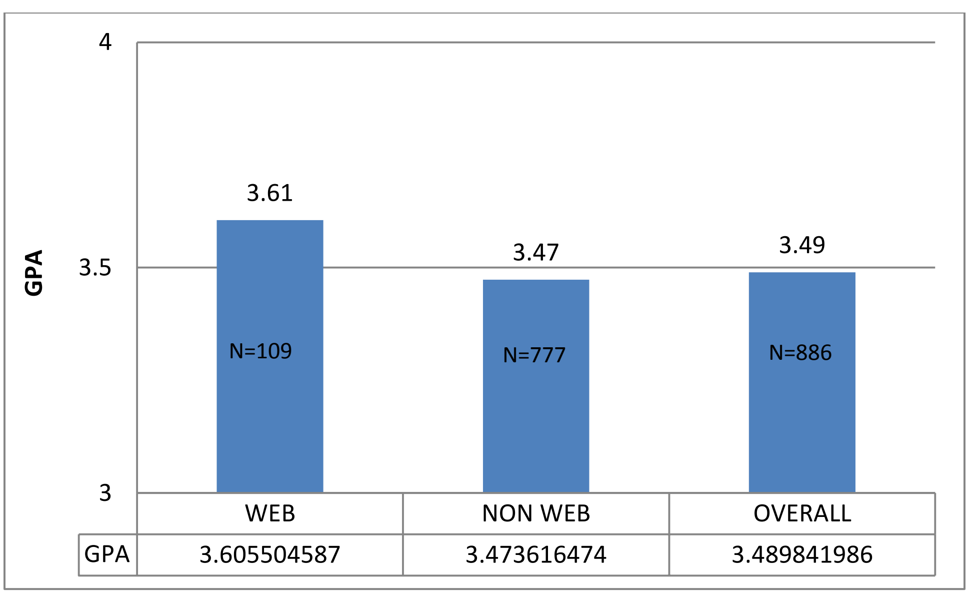

Figure 4: Comparison of course grade point averages.

Lessons Learned/Best Practices

There are a few lessons learned from the implementation and piloting of these undergraduate courses:

1) A two-plus-two electrical engineering program benefits from the cooperation of two-year colleges by offering at least some of the sophomore courses outside of the four-year institution. This approach also allows four-year institutions to focus resources on the upper-level core and elective courses.
2) Some type of certification process is essential for maintaining a consistent standard of quality.
3) It is optimistic to have faculty build and teach courses, especially when adjunct instructors are involved on a part time basis. It is a good practice then to pair seasoned faculty with adjuncts or junior faculty, if this approach is used.
4) Online programs offer a unique opportunity to offer courses during the summer, giving the students an extra window to stay on track and meet their graduation goals.
5) Pre-course training on specialized laboratory equipment and software is important to keep the pace of online learning manageable.

The course design and building phase is extremely integral to developing a successful online program. It is important to create high-quality online courses to protect the university's brand which means faculty need the time and training, and support to plan and design courses that will be both rich in content and instructional strategies, with a variety of multimedia tools and technologies to encourage student engagement and learning. One of two strategies that need to be considered during the course building stage is to create a cadre of course builders assigned to plan and develop the required courses. Alternatively, a university could consider providing resources to hire teaching fellows or adjunct faculty, while freeing up full-time faculty to build their respective online courses.

Summary

As a result of this pilot study, with special care and proper resources, conducting a fully online program appears to be a viable endeavor. It is markedly different in terms of the pedagogy, instructional tools and administrative overhead required. Certain institutional commitments and resources must be in place in order to have a program developed to fruition. A transition from pilot to production of this program will be fully implemented commencing in the Fall of 2012. It is hoped that efforts such as this may help to lead the way in establishing Electrical Engineering as a competitive online undergraduate discipline, amongst those already being offered or planned.

Acknowledgment

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