AC 2010-1314: ASSESSING A PROJECT-BASED PROGRAM AFTER A DECADE

Mark Cambron, Western Kentucky University
Stacy Wilson, Western Kentucky University
Introduction

The Department of Engineering at Western Kentucky University (WKU) was given the rare opportunity to develop entirely new engineering programs. On July 17, 2000, the Council on Postsecondary Education (CPE) approved the Strategy for Statewide Engineering Education in Kentucky. This strategy is intended to address two primary issues: 1.) the need to increase the number of baccalaureate engineers in the Commonwealth of Kentucky, and 2.) the need to address regional issues of access and productivity in engineering education. In response CPE’s strategy engineering programs in civil, electrical and mechanical engineering were jointly developed between our Department of Engineering and the two Research 1 Universities in the State. A project based curriculum was developed.

The Department of Engineering offers degrees in civil, electrical and mechanical engineering. This paper focus on the electrical engineering program. The University of Louisville (UofL) is our partner in the EE program. In 2004, our first cohort of engineering students graduated and we were accredited. In 2010, we will have our second ABET accreditation visit. It seems like a natural time for the Electrical Engineering Program to assess a growing and dynamic program. In this paper we examine how the Electrical Engineering program has grown over the past 10 years. A study of FE results for the entire history of the program is given. FE results from an undergraduate only project-based curriculum are compared to national results. Discussions include the positive and negative aspects of our relationship with our partner.

Development of Project-Based Curriculum in Electrical Engineering

The Department of Engineering’s faculty are focused on undergraduate education. The Department of Engineering’s mission revolves around Project Based Learning. Faculty engage students in activities to support development of a clear understanding of engineering practice. An excerpt from the departmental mission statement exemplifies the focus:

“*The mission of the Department of Engineering is to produce, as its graduates, competent engineering practitioners. An engineering practitioner is one who has a foundation of basic science, mathematics, and engineering knowledge, combined with practical knowledge and experience in applying existing technology to contemporary problems.*”

Project based learning was the guiding principle in the development of the EE curriculum. The curriculum insures that students are involved in project based activities during their entire undergraduate experience. These experiences include lab classes, design classes and class projects. In addition, students are encouraged to be involved in industry sponsored projects outside of the classroom. Many of the EE students also participate in the annual IEEE regional robotics competition (Figure 1). Engaging students with the concrete, hands-on, and real-world problems is a great motivator and learning opportunity.
The EE program has strong emphasis on the implementation of design experiences. The 4-year curriculum has a design course each year with two in the senior year. The role of these courses is to bring together material from various courses and form an integrated curriculum. The design course sequence is composed of four one semester design courses. In addition, the design experience culminates with a senior capstone design experience. Many of these projects are done with the support of local industry. Students prepare for outstanding professional leadership by participating in real-world projects undertaken by multidisciplinary teams using state-of-the-art tools and facilities. EE faculty are rewarded and required to engage students in activities to support the development of a clear understanding of engineering practice.

**Role of Design Courses**

An important part of the EE Program’s project based curriculum is the design sequence. This five course sequence culminates with a capstones experience. The first design course, **EE Design I**, introduces students to the university and the EE program. Students are exposed to Electrical Engineering using a robot project (See Figure 2). The students are introduced to departments prototyping facilities and programming skills.

**EE Design II** further builds on the project-based mission. This course is focused on using the departmental print circuit board facilities. In addition students are exposed to Matlab. Shown below in Figure 3 is a digital clock built in this course.
In EE Design III, students are assigned to teams. Each team is assigned a unique design project and must solve and implement a design problem throughout the semester. These projects are often industrially supported. Recently, some projects have been extended into the senior year. EE300 is taken in the spring semester before the year long senior design sequence and is an important foundation to the senior project experience.

The first course of the senior year experience is EE Design IV. During this course, students thoroughly plan their capstone project. At the beginning of the semester, students are placed on teams and are assigned projects. Each of these projects has a sponsor external to the EE faculty. Some of the projects are funded through industry sponsors and others through grants. The students interact with the faculty as technical sponsors for their projects and also interact with the industry liaisons. During this semester, the following topics are presented: teamwork skills, steps in effective design (understanding the problem, brainstorming, research, preliminary design, Gantt charts/project planning), manufacturability, assemble, affordability, reliability, and sustainability. By the end of the semester, the students have completed the project proposal.

The second course in the senior capstone experience is EE 401. Students will demonstrate their ability to design, build, and test a system to meet specified criteria. Also, students will demonstrate their ability to communicate their project design and results in a written format and in an oral presentation. The entire semester is spent implementing the capstone project. The end of the semester culminates with presentations and demonstrations to the faculty, industrial
advisory board members, and fellow students. These presentations are assessed by all three groups. The teams also present their results at their sponsoring industries.

**Joint Program Architecture**

The engineering programs in civil, electrical and mechanical engineering were jointly developed between the Department of Engineering and the two Research 1 Universities in the State. It is interesting to note that only engineering students housed at WKU are involved with the joint programs. The meaning of a joint program is defined by the CPE:

> A joint program is a program that is mutually sponsored by two or more institutions leading to a single credential or degree, which is conferred by both or all participating institutions. None of the participating institutions delivers the entire program alone. All participating institutions and organizations share responsibility for all aspects of the program’s delivery and quality. The credential indicates the joint nature of the program. The program is registered on the Council’s Registry of Degree Programs in an enrollment and degree-granting category for each institution participating in the joint program.\(^{12}\)

Curricular matters are jointly decided between the faculty of both institutions. The host institution is responsible for all administrative matters not associated with the curriculum. The deans and provosts of the institutions involved in the programs form a Steering Committee to discuss higher-level issues and to settle conflicts.

This joint program relationship provides both opportunities and challenges. Perhaps the most significant opportunity is that it provides engineering students at WKU access to a variety of faculty with specialties beyond those of the departmental engineering faculty. The EE program has 4 full time tenured (or tenure track) faculty. Our partner has 22 Electrical and Computer Engineering (ECE) faculty with a large range of expertise. They provide between 16-19 hours of classes annually. Potentially students are exposed to more faculty teaching classes in their expertise. However, currently students are required to take at least 16 hours of classes from our partners. The disadvantage of this rule is that the students are given little choice of classes to reach this requirement. The result is that students see their distance classes as an additional hurdle that must be overcome and not an opportunity to choose courses of interest. One of the goals of the joint relationship is to attract more students into the graduate programs at the Tier I institutions in the state. However, currently the majority of students pursing graduate degrees in EE have chosen to go out of state for graduate studies.

Another significant challenge is the contrast in missions between the two institutions. One institution is focused solely on undergraduate education while the other institution has graduate programs and more extensive research programs. A challenge was to develop a unique curriculum at the host institution. Our mission is project-based learning with engagement with industry as opposed to the research missions of our partner. Our partners have been very supportive of this goal.

The joint program structure also provided another benefit. Prior to the creation of the engineering programs, our university offered four engineering technology programs. Those technology programs were discontinued when the engineering programs were created. Our partner played a valuable role in ensuring that the new engineering programs were being offered with the appropriate rigor. They were instrumental in the hiring process of new faculty.
This joint program relationship is unique among institutions of higher education. It is a program in which two separate institutions jointly deliver an engineering program at one of the institutions. The official transcripts for graduates are official transcripts of WKU with the following statement added “Degree jointly awarded with University of Louisville.” The diplomas of each graduate also have the names of both institutions on them.

The joint programs in engineering provide an exciting opportunity for engineering education. The department of engineering offers unique undergraduate only programs that are quite different from the other engineering programs in the state. The relatively short time in which these joint programs were created is a testament of the support and commitment to the success of the programs.

![Electrical Engineering Enrollment](image)

**Figure 5: EE Enrollment Figures**

**Growth of the EE Program**

The EE program has grown consistently over the past few years. Enrollment and graduation data are given in figures 6 and 7. Students can declare themselves any major at WKU. Thus the enrollment data includes many students that never reach a circuits class. The data is useful as a measure of the growth of the program. Over the past 6 years the number of the students in the program has doubled.

![Electrical Engineering Graduates](image)

**Figure 6: EE Graduation Figures**
In the spring of 2004 we graduated our first 3 electrical engineering students. 51 electrical engineering students have graduated since 2004. This spring we anticipate 17 more graduates. The figure above shows the graduates each of the past 5 years.

**Fundamentals of Engineering Exam Results**

The Fundamentals of Engineering (FE) examination is a step in the professional licensing of engineers and was developed to measure minimum technical competence. The National Council of Examiners for Engineering and Surveying (NCEES) oversees the development, distribution, and grading of the FE Exam. The FE exam is a pass/fail exam. The FE exam is a nationally-normed exam. It also provides information concerning the achievement of students taking the test relative to state and national averages. The FE examination is an extremely attractive tool for use as part of an assessment process.

EE faculty compare our student’s FE results to results of other EE students nationally. In particular we are interested how are students do in the upper division classes that our students are required to take. In addition we wish to compare our students in the areas of mathematics and circuits as important foundational courses. Our students are not required to take the exam. The students are encouraged to take the exam and study sessions are provided. The figures below show the comparison of our students to national averages in the areas of control systems, power, mathematics, circuits, signal processing and digital systems. The data is used as part of our accreditation process. It is important as a new program to compare the performance of our students against national averages.

EE students generally earn a minor in mathematics and several students double majored in mathematics. However, EE students met or exceeded national averages in mathematics only 3 of 8 exams. This is a concern that needs to be monitored. EE students take two required courses in circuits and a course in electronics. EE students have met or exceeded national averages in 6 of 8 exams.

![Figure 7: Comparison to National Results in Mathematics and Circuits](image)

The EE students are required to take in course in Control Systems Theory in their senior year. Our students have met or exceeded national averages in 5 of the 8 exams. EE students take required course in power. Electives in Power Electronics or Power II are offered once every other year. The students have only met or exceeded national averages on 3 of 8 exams.
Recently a pre-requisite of EM Fields and Waves was added to the Power course. This change will allow for more material to be presented in the course.

Figure 8: Comparison to National Results in Power Systems and Control Systems

EE students take a required course in Signal and Systems and Microprocessors during their junior year. They take a course in Digital Signal Processing as seniors. Students also take a required course in Digital Circuits as freshmen. EE students met or exceeded national averages in digital systems on 4 of 8 exams. EE students have met or exceeded national averages in 5 of 8 exams in Signal Processing.

Figure 9: Comparison to National Results in Signal Processing and Digital Systems

Conclusions
On July 17, 2000 the CPE approved a Strategy to expand the engineering opportunities in the Commonwealth of Kentucky. Joint engineering programs were established between WKU and the two Research 1 Universities in the state housed at WKU. The new engineering programs were developed with a focus on project based learning. In 2004 the EE program graduated its first cohort of students.
This paper discussed the unique joint program developed at WKU. Some of the opportunities and challenges were discussed. Complete histories of our FE results were discussed. The table above shows the pass rate for our EE students compared to national pass rates.

The joint programs in engineering provide an exciting opportunity for engineering education. The department of engineering offers unique undergraduate only programs that are quite different from the other engineering programs in the state. The relatively short time in which these joint programs were created is a testament of the support and commitment to the success of the programs.

**Bibliography**


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Table 1: Electrical Engineering FE Results

