Creation of an Assessment Plan for a Project Based Electrical Engineering Program

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Abstract

A joint program in Electrical Engineering has been created with Western Kentucky University (WKU) and the University of Louisville (UofL). The program resides at WKU with UofL faculty delivering 16-24 hours into the curriculum through distance learning methods. The focus of the new EE program is a project-based curriculum. The mission of the new program is to build a foundation of knowledge in electrical engineering by integrating a variety of project experiences at every level throughout the curriculum. The program is to be relevant to the region and to produce graduates who can immediately contribute to the profitability of the their employer. An assessment plan has been created to meet the outcomes of the program. A variety of assessment measures are used in this plan. These measures and their impact on the joint program will be discussed in this paper.

History

In 2000, the Commonwealth of Kentucky's Council for Postsecondary Education (CPE) created the Statewide Strategy for Engineering Education. This document was signed by Western Kentucky University (WKU), University of Louisville (UofL), and University of Kentucky. In this document, the framework for a joint electrical engineering program was created between Western Kentucky University and the University of Louisville. Also, the CPE created mechanical and civil engineering programs between Western Kentucky University and the University of Kentucky.

The new EE program resides at WKU who is responsible for the various administrative responsibilities associated with the program. The CPE mandated in the framework that 16-24 hours of the program be offered by UofL. Currently the hours are being offered into the program via interactive television (ITV). Faculty from UofL have served in an advisory role in the creation of the program and curricular issues, and have served on the search committees for three of the four WKU EE faculty. The WKU and UofL faculty mutually agreed on the courses to be offered by UofL into the curriculum. The first classes taught in the new EE program were offered Fall 1999. The first students graduated from the program in May 2004.

Project-Based Program

The focus of the new WKU Department of Engineering is project-based engineering education. An excerpt from departmental mission statement exemplifies the focus clearly[1]:

> "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. "

The mission of the new EE program is to build a foundation of knowledge in electrical engineering by integrating a variety of project experiences at every level throughout the curriculum. The program is to be relevant to the region and to produce graduates who can immediately contribute to the profitability of their employer. The roles of the student as learner, observer, assistant, and practitioner have been clearly defined and articulated for this environment[2].

The new Electrical Engineering curriculum was created by studying the Electrical Engineering, engineering science, mathematics, and science requirements of several ABET accredited EE programs with similar missions. The program itself was the result of much research and discussion as the faculty developed a plan to implement the program and the assessment processes. This planning and discussion took place form 1998-2000 and most of the review from 2001-2004 has focused on the quality of the new engineering degree program and the preparation for its accreditation by ABET. The initial ABET visit for this program occurred November 2004.

During the summer of 2002, faculty members of the EE program drafted the initial version of program outcomes and began to develop measurement tools. That work continued through the fall semester of 2002 and culminated with a review of external consultants in the spring semester of 2003. The outcomes were presented to the program advisory committee in both the spring and fall meetings of the 2002-2003 academic year. Implementation of the assessment processes began in the fall semester of 2001 and continues.

EE Program Objectives and Outcomes

The objectives for the WKU EE program were developed with the industrial advisory board to support the mission of the program and department. The objectives are as follows:

Objective 1: Our graduates demonstrate a foundational knowledge and understanding of topics in electrical engineering.
Objective 2: Our graduates are application-oriented problem solvers, accomplishing cost-effective solutions through sound engineering practice.
Objective 3: Our graduates are involved in continuing professional development and lifelong learning. Our graduates pursue professional licensure.
Objective 4: Our graduates practice engineering in a professional manner, demonstrating awareness of legal and ethical responsibilities and contemporary issues.
Objective 5: Our graduates have the ability to effectively communicate their ideas and designs, including economic justifications, to diverse audiences. Communication media include oral, written, graphical, and visual means.
Objective 6: Our graduates contribute to the regional economic development through their professional practice.

The faculty then created the following outcomes to support the objectives above:

> **Outcome 1A**: EE graduates possess knowledge of core EE topics including circuit analysis, electric machines, microprocessors, and control systems, and can develop mathematical representations of systems.
> **Outcome 1B**: EE graduates use their understanding of science and mathematics to support their work in solving electrical engineering problems.
> **Outcome 2A**: EE graduates plan and implement cost-effective electrical engineering designs using modern engineering equipment and software.
> **Outcome 2B**: EE graduates can effectively work with and on multi-disciplinary teams and understand the importance of teamwork in an engineering environment.
> **Outcome 3**: EE graduates are aware of trends in electrical engineering and are engaged in a path of life-long learning.
> **Outcome 4**: EE graduates are committed to excellence in all professional endeavors and apply their understanding of ethics to solve engineering problems.
> **Outcome 5:** EE graduates effectively communicate technical material in an oral, written, visual, and graphical manner.
> **Outcome 6:** Regional employers will employ WKU electrical engineering graduates.

Overall, the Program Outcomes closely mirror the Program Educational Objectives and they are entirely consistent with the goals of the Department of Engineering. In essence, the outcomes are directly supportive of the objectives.

The WKU Electrical Engineering Program Outcomes detail the skills and expected knowledge of students at the time of graduation. ABET Criterion 3 states that engineering programs must demonstrate that students have attributes listed as items (a) through (k)[3]. The ABET Program Criteria (Criterion 8) lists additional requirements for graduating Electrical Engineering students[3]. The Electrical Engineering department has combined these outcome requirements into the list shown below. The first eleven are the ABET (a) through (k) and the last three are derived from the ABET Program Criteria, (l) through (m).

ABET Criteria 3

(a) an ability to apply knowledge of mathematics, science, and engineering

(b) an ability to design and conduct experiments, as well as to analyze and interpret data

(c) an ability to design a system, component, or process to meet desired needs

(d) an ability to function on multi-disciplinary teams

(e) an ability to identify, formulate, and solve engineering problems

(f) an understanding of professional and ethical responsibility

(g) an ability to communicate effectively

(h) the broad education necessary to understand the impact of engineering solutions in a global and societal context

(i) a recognition of the need for, and an ability to engage in life-long learning

(j) a knowledge of contemporary issues

(k) an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.

ABET EE Program Criteria (Criterion 8)

(l) knowledge of probability and statistics

(m) knowledge of mathematics through differential and integral calculus, basic sciences, computer science, and engineering sciences necessary to analyze and design complex electrical and electronics devices, software, and systems containing hardware and software components

(n) knowledge of advanced mathematics, typically including differential equations, linear algebra, complex variables, and discrete mathematics.

Table 1 below maps the WKU EE Program Outcomes to the ABET Criteria 3 a-k requirements.

Table 1: Program Outcomes Versus ABET Criterion 3 Outcomes

	a	b	c	d	e	f	g	h	i	j	k	l	m	n
Outcome 1a	x	x											x	x
Outcome 1b	x	x			x							x	x	x
Outcome 2a		x	x								x			
Outcome 2b				x										
Outcome 3									x	x				
Outcome 4						x		x						
Outcome 5							x							
Outcome 6														

Assessment Instruments

A variety of assessment instruments were used in support of the outcomes assessment process. These instruments include course review, surveys, industrial advisory board feedback, results from the Fundamentals of Engineering Exam, and rubrics. These instruments will be discussed below. Table 2 below shows the relationship between the assessment instruments and the program outcomes. The combination of these instruments has been effective in assessing the WKU EE program outcomes.

Table 2: Assessment Instruments used to Evaluate Program Outcomes

	Outcome 1A	Outcome 1B	Outcome 2A	Outcome 2B	Outcome 3	Outcome 4	Outcome 5	Outcome 6
Course Review	X	X	X	X	X	X	X	
Surveys	X	X	X	X	X	X	X	X
IAB Participation							X	X
FE Exam Results	X	X			X	X		
Rubrics	X	X	X	X		X	X	

Course Review

Course Review was implemented after the fall 2001 semester. Immediately following each semester, the EE faculty will conduct the course review process. The purpose of this review is to:

1. ensure that course outcomes are being met;
2. examine student readiness for each course (relevance of pre-requisites),
3. ensure that the material specified in the syllabus is being taught,
4. compare the integration of topics throughout the curriculum, and
5. evaluate the success of previous assessment changes.

Each faculty will create a course review folder for each class taught ever semester. This folder will contain the following information:

1. A current syllabus.
2. Identification of the textbook(s).
3. Copies of materials provided to students.
4. Copies of examinations.
5. Example graded work.
6. Grade distribution.
7. Other material or discussion deemed important by the instructor including experiments (if applicable).

Through the semi-annual course review process, the Electrical Engineering Degree Program requirements have been modified as a result of our internal course assessments. The effectiveness of the course review process has been documented[4].

Course review is a very valuable component of the assessment plan. Through this process, the faculty of the EE program discuss each course offered in the curriculum at least once a year. Therefore, continuity in the curriculum is easier to achieve. Also, faculty are aware of what their colleagues are covering in classes. The course review process has greatly improved the quality of the WKU EE program. Faculty from UofL teaching into the program have also

participated in the course review process. The results of this interaction has provided valuable feedback for improving the experience of the students and meeting the program outcomes.

Surveys

A variety of surveys are administered to various constituent groups. These surveys include a EE program graduate exit survey, an alumni survey, and an exit survey administered by the university. The program exit survey is administered to graduating students within the last month prior to graduation. This survey addresses the students' perceived competency in all six outcomes. Graduating seniors rank their performance of each outcomes on a scale of 1-10 with 10 being the best score and 1 the worst. Target scores of 8.0 have been established by the program faculty as a means of judging outcome competency.

Alumni will be surveyed three years after graduation to further assess the success of the EE program in meeting the objectives. This survey addresses the graduates' perceived competency of all six program educational objectives. Alumni rank their performance of each outcomes on a scale of 1-10 with 10 being the best score and 1 the worst. Target scores of 8.5 have been established by the program faculty as a means of judging outcome competency.

Graduating seniors take the WKUses survey (Western Kentucky University Student Engagement Survey). This survey contains a variety of generic questions regarding the students' experiences at WKU and questions concerning ABET Criteria 3, A-K. Target scores on the survey have been established as one means to judge student competency in the various outcomes.

Industrial Advisory Board Participation

The EE program has an industrial advisory board (IAB) which is composed of industrial representatives from regional university. The IAB members are usually people who are engineering managers and most of the IAB members hold degrees in electrical engineering. The EE IAB meets twice a year. The IAB is used to assess various aspects of the EE program. In the past, the IAB has developed and approved the program objectives and outcomes and approved the EE assessment plan. The IAB assessed the communication skills of the graduating seniors during the May 2004 meeting. Each spring, it is planned that the board will continue in the assessment of the graduating students.

Also, the IAB is surveyed each year at the fall meeting. This survey determines if regional industry is employing the graduates of the EE program. Board members rank the performance of WKU EE graduates regarding each outcomes on a scale of 1-10 with 10 being the best score and 1 the worst. Target scores of 8.5 have been established by the program faculty as a means of judging outcome competency.

Fundamentals of Engineering (FE) Exam

EE students are encouraged to take the FE exam in the semester prior to graduation. One method of demonstrating that students are engaged in lifelong learning (Outcome 3) is that the

number of WKU EE students taking the FE exam is equal to the national average of EE students taking the exam. Also, the scores of the WKU EE students are compared to the national, state, and regional averages in the areas of mathematics, ethics, and foundational EE areas such as electric circuits, controls systems, digital systems, power systems and signal processing to assess Outcomes 1A and 1B. Table 3 below lists the data from the previous year. This information is a useful data point for assessing whether or not an objective was met along with the other assessment measures.

Table 3: 2004 FE Results

	WKU Average	State Average	National Average
Electrical Circuits	83%	61%	65%
Analog Electric Circuits	33%	28%	34%
Control Systems Theory & Analysis	33%	46%	42%
Digital Systems	67%	54%	58%
Power Systems	33%	47%	32%
Signal Processing	67%	56%	36%
Mathematics	79%	77%	72%
Ethics	60%	55%	61%

From this data, it can be seen that the WKU EE student performance was lower in the areas of Control Systems and Power Systems. This information can be used along with other assessment data to draw conclusions about whether or not the various outcomes were met. However, it should be noted that only one of graduates took the FE exam last year. Therefore, there is little statistical value in the table above. This information was not used in the assessment of the outcomes last year because of the small sample size. As more students take the exam, the data will be more useful to the faculty for assessment purposes.

Rubrics

A variety of rubrics are used to evaluate the competency of students in meeting various outcomes. Each rubric is a four-element rubric with the following possible scores: novice, apprentice, proficient, exemplary. The rubrics are used to evaluate the following: fundamental knowledge; math and science knowledge; design skills, experimental skills; teamwork; professionalism and ethics; written, visual, and graphical communications; and oral and visual communications. Benchmark rubric scores have been established by the faculty for each outcome. Some benchmark scores are between apprentice and novice for lower courses while a higher standard is set for upper division courses.

Each semester samples of student work is collected before it has been graded. The material is then assessed by the faculty using the appropriate rubrics. The material collection plan was designed so that one piece of work is assessed for multiple outcomes. The scores are then averaged for each rubric and used as one measure for assessing the success in meeting an outcome.

For example, one assessment measure of Outcome 1A is scoring final exams with a rubric. The rubric used to score this outcome is shown in Table 4. The faculty have determined that the final exam questions from the following classes will be assessed:

- EE 211 (Circuits and Networks II)
- EE 330 (Introduction to Power Systems)
- EE 460 (Continuous Controls Systems)

The target average score for the material collected from EE 211 is 2.5. The target average scores for the material collected from EE 330 and EE 460 are 3.5. These scores are set with the expectation that student knowledge will increase as the students progress toward graduation. The following assessment results were obtained for material collected during the previous academic year:

- EE 211 material rubric average score was 3.00. (A sample of 3 pieces of student work was examined. A total of 10 students were enrolled in the class.)
- EE 330 material rubric average score was 3.75. (A sample of 4 pieces of student work was examined. A total of 5 students were enrolled in the class.)
- EE 460 material rubric average score was 3.67. (A sample of 3 pieces of student work was examined. A total of 3 students were enrolled in the class.)

It can be seen that the rubric scores exceeded the target scores for these classes. The faculty can then use these scores along with the other assessment data to determine the success of achieving the stated outcomes.

Table 4: Outcome 1A Rubric

	Exemplary (4)	Proficient (3)	Apprentice (2)	Novice (1)	Score
Circuit analysis	Ability to choose best method to solve circuit and obtain correct answers.	Can use specific analysis methods to obtain correct answers	Able to use some circuit analysis techniques	Unable to correctly solve circuits	
Electric machines	Able to choose appropriate electric machines for specific situations	Understanding of types of electric machines and able to correctly solve electric machine problems	Able to solve some electric machine problems	Unable to correctly solve electric machine problems	
Microprocessors	Able to successful program and use a microprocessor to solve engineering problems	Somewhat successful at microprocessor programming	Minimum ability to program a microprocessor	Cannot program microprocessor	
Mathematical representations of systems	Able to develop accurate mathematical representation of system	Able to develop semi-accurate mathematical representation of system	Little ability to develop mathematical representation	Unable to develop mathematical representation	

Assessment Processes Used to Evaluate Program Outcomes

The Electrical Engineering faculty members use a multi-loop assessment process to evaluate the overall program outcomes and objectives shown in Figure 1. The outer-most loop provides the assessment of the Program Educational Objectives. The interior loops represent the assessment of the Program Outcomes. The inner loop represents the course review process. Course review occurs at the end of every semester with all WKU EE faculty and any UofL faculty who have been teaching courses in the EE program that semester. This includes the evaluation of survey data, rubrics, and other information. The results of the assessment loops are then combined to determine if the program outcomes and thus objectives have been met. The results of these activities and the impact on the Electrical Engineering Program will be discussed.

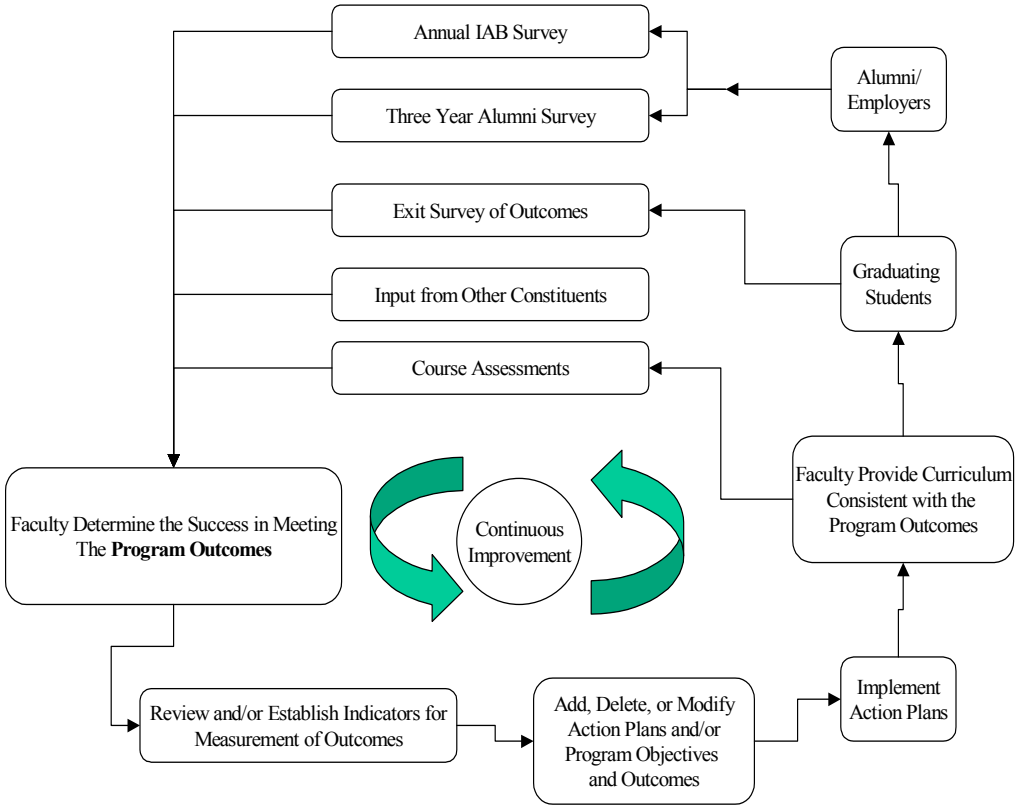

Figure 1: Assessment of the WKU EE Program Outcomes and Objectives

In the assessment of the Program Outcomes, the faculty members have established indicators for measuring the outcomes which have been previously described. Having determined the results of assessing the Program Outcomes, action plans are put in place and assigned to faculty members for oversight and responsibility. Faculty implemented the action plans and provided a curriculum to the students consistent with the program goals and objectives. Faculty and students regularly assess the curriculum, and the results of the assessments are used

to improve the courses, and modify the course outcomes. Eventually, students graduate from the program and are surveyed to assess their knowledge, skills, and attitudes. These assessments occur three years after their graduation, and are used to gather information on job placement and title, employer respect for WKU graduates, number pursuing advanced degrees, and other information relevant to the curriculum. The Electrical Engineering faculty reviews this information, along with input from other constituents, such as the IAB and then determines how well each objective was met. At this point the process repeats.

Results of Assessment Plan

Each of the program outcomes has been evaluated to determine if the outcomes were achieved. These outcomes were evaluated using assessment measures previously described. The table below records a history of the effect of the assessment plan on the EE program.

Table 5: History of Changes to the EE Program Due to Assessment Process

Semester	Issue	Corrective Action Taken	Program Outcome
F01	Course pre-requisites/co-requisites	Many course pre-requisites/co-requisites were examined and updated	1A
F01	Discovered need for text in freshmen seminar	Text was chosen and required for next offering.	1A
F01	Increase difficulty of project and focus more on PLC programming in EE200 (EE Design II).	Project was restructured for next offering and more programming was included.	1A,2A, 2B
F01	Unprofessional presentations in freshmen seminar class	Included material to teach students to create professional presentations.	5
S02	No course review documentation on courses	Implemented requirement of course review documentation other than syllabus, graded material, handouts (see course review documentation)	All
S02	Need to modify EE 180 (Digital Logic) course outcomes to better support program objectives	Course outcomes modified before next offering.	1A
S02	Poor textbook for EE 220 (Electronics)	New textbook was required for electronics course	1A
S02	More labs needed for EE 220 (Electronics).	More lab experiments were added to the EE 220 (Electronics) course before the next offering.	1A
F02	Inclusion of PLC material in EE 200 (EE Design II)	Removed PLC material from EE 200 (EE Design II) and added circuit design material for next offering.	1A, 2A
F02	Need more technical writing in EE 101 (Freshmen Seminar).	More technical writing was incorporated into next offering of EE 101 (Freshmen Seminar).	5
F02	Need more technical writing in EE 200 (EE Design II).	More technical writing was incorporated into next offering of EE 200 (EE Design II).	5
F02	EE 380 (Microprocessors) course content needs to be revised.	Content revised to better meet the outcomes of the course.	1A
S03	Examined all five design courses	Restructured courses to better meet mission and objectives of program.	2A
F03	UC 101 (Freshmen Seminar) no longer to be offered by university. Need to create freshmen seminar course for EE students.	Restructured freshmen seminar course (UC101) and created EE 175 to meet university requirements for freshmen experience and EE program objectives.	1A
F03	EE 460 (Control Systems) textbook had excellent problem set but inadequate text	A new textbook has been selected for the fall EE 460 (Control Systems) offering	1A, 1B
S04	Circuits text was insufficient for EE 211 (Circuits II) component of class	A new textbook was found and used in the EE 210/211	1A

Conclusion

The new EE program at Western Kentucky University has been designed on the foundation of project-based education. This program is a joint program with the University of Louisville. The assessment plan has been designed to ensure that the mission of the program is achieved. Thus far, the assessment plan has produced results which have been used to improve the quality of the WKU EE program.

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