Assessment Processes

Department of Electrical and Computer Engineering

Fall 2014

Introduction

The assessment process in the Electrical and Computer Engineering (ECE) Department at Utah State University is designed to provide information about how the courses work together to help students attain program educational objectives (PEO) as well as ensure that the criteria of the ABET accreditation body are attained. The process is designed to be a minimal burden on the faculty while leaving flexibility to adjust courses and curriculum to changing needs.

The assessment effort in the ECE department serves multiple purposes. One purpose is to ensure that the overall curricular needs of the department are met: that the courses taught cover the outcomes, that there are no holes in the curriculum, and that courses flow together well. Another purpose is the ensure that the ABET outcomes (a)–(k) of ABET Criterion 3 are attained by each student. Another purpose is to work to ensure that the PEOs are being attained by graduates. Because of these multiple purposes, a variety of input data are used in the assessment cycle. These include:

- Faculty course assessments
- Alumni survey
- Industrial advisory committee
- Senior exit survey and interviews
- Special assessments of (a)–(k) outcomes

These assessment processes are under the supervision of the department head, who delegates operational responsibility to the chair of the Assessment Committee. Standing committee structures involved in the assessment process are described in section 1. Section 2 reviews the PEOs for the two programs in the department and describes the roles of constituents in establishing the PEOs. Section 3 discusses the student outcomes and their relationship to the PEOs. Section 4 provides details on the assessment and evaluation processes used by the department. The assessment process is summarized in Section 5.

1. Department Governance Structure

The ECE department has three standing committees, each with its own chair. These committees are the assessment committee, the curriculum committee, and the graduate committee. The assessment committee is charged with establishing assessment tools, gathering the information from the various assessment tools, evaluating the information, and reporting back to the committees and faculty to close the loop. The curriculum committee is charged with ensuring that course offerings support timely completion of degree requirements and ensuring that courses having the necessary content are taught. The graduate committee is responsible for graduate student admission, oversight of graduate student research, and compliance with graduate student requirements. (See Figure 1.)

Because of the close relationship between assessment and curriculum, the chair of the curriculum committee is a member of the assessment committee, and the chair of the assessment committee is a member of the curriculum committee. A great deal of coordination and information interchange takes place directly between the assessment and curriculum committees via the two chairs, making the process more agile while eliminating committee work. This governance structure makes issues discovered by assessment immediately accessible to the department head and chairs of other committees.

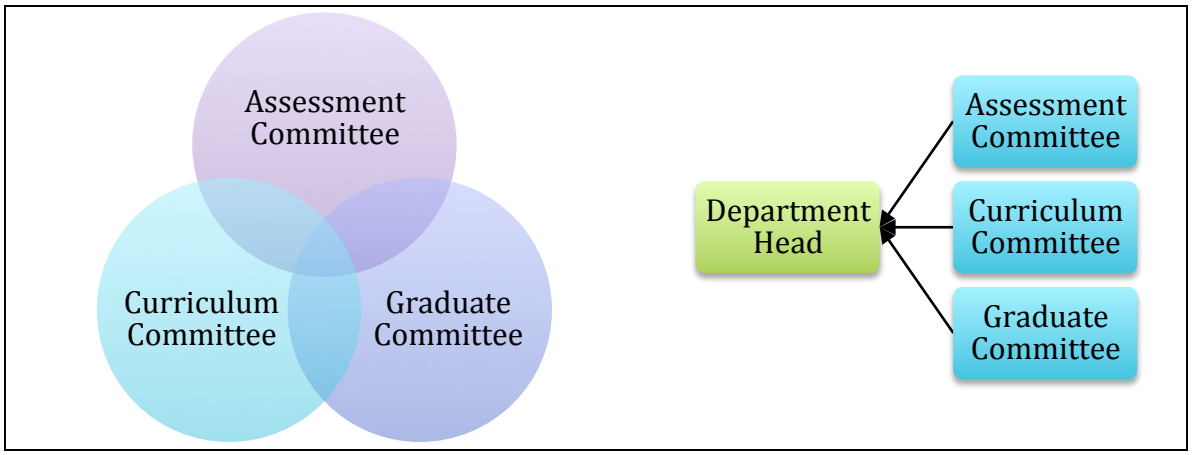

Figure 1. Department governance committees.

2. Program Educational Objectives

Program educational objectives are "broad statements that describe what graduates are expected to attain within a few years of graduation." (Criteria for Accrediting Engineering Programs," ABET 2013-2014.) As these are broad statements and goals, and not particular technical skills, it was decided that both the Electrical Engineering Program and the Computer Engineering Program should share the same objectives.

Assessment processes within the ECE Department have the PEOs reviewed every few years. This review involves all of the constituents and takes opportunities for inputs from other sources as well. The paragraphs below describe the roles of the constituents.

Faculty

The faculty have the collective responsibility for establishing the PEOs. The Department Assessment Committee is allocated time on the agenda for faculty meetings each month. At intervals, proposals to modify the PEOs are presented to the faculty at these meetings by the Assessment Committee. Following parliamentary procedures, motions are made, discussed and voted on.

The annual ECE Faculty Retreat is a day-long faculty meeting held each August before the start of each school year. The Assessment Committee is allocated time on the retreat agendas.

Each year the assessment processes in the department are reviewed. This provides opportunities to instruct newly hired faculty about department assessment processes and provides reminders about the process to faculty not involved in the day-to-day activities of the Assessment Committee. The PEOs are reviewed. From time to time, the PEOs are reviewed and discussed with an eye to updating them at the faculty retreat. The department mission statement is also reviewed and the consistency of the PEOs with the mission statement is discussed.

Industrial Advisory Committee (IAC)

The IAC, which provides representation of industry and alumni, meets twice most years. This group of professionals are usually alumni of our program and are relied upon for inputs and feedback with industrial perspective. The IAC is an important part of the assessment processes in the department. Before implementing changes to the PEOs, we solicit their opinions on proposed changes. Over time the IAC has provided valuable guidance on curriculum and assessment of the program. Due to the diverse needs of the companies represented on the IAC, a multitude of views are expressed and debated. This process has helped us arrive at the current PEOs. Inputs from the IAC are presented to the faculty during faculty meetings.

In many cases, members of the IAC are managers at companies where our new graduates work. Thus they are uniquely positioned to provide insights on how graduates of our program are performing in their organizations. This information is presented to the faculty during faculty meetings, and this information is forwarded to the curriculum committee where curriculum changes can be considered to correct weaknesses.

Recent History

In its meeting in Spring 2012, the IAC was asked to consider the adequacy of the PEOs. The following was sent to members of the IAC for preparation of the discussion (email dated February 21, 2012):

“This year, in preparation for the upcoming ABET review visit in two years, I would like to take another look at the program educational objectives of the department. This is something that we have taken IAC input on in the past, but it should be reviewed periodically. We’ll talk about ours, make some comparisons with others’, and see how these objectives fit with your needs as industry constituents.”

Along with this were sent the existing PEOs and example PEOs from other institutions as a basis for discussion. In our IAC meeting held February 24th, 2012, we discussed PEOs. The IAC provided some input, and tentative revisions were made. These revisions were

presented that Spring to the faculty in faculty meeting, and PEOs were adopted by faculty vote. Five PEOs were accepted.

In Spring 2013, an experienced ABET reviewer visited campus. He reviewed the PEOs and indicated that they could be streamlined and clarified. Based on this input, further research into PEOs at other institutions was performed. The current PEOs were presented to the IAC, then presented and approved by the faculty in faculty meeting September 2013.

The process for modification of the PEOs is diagrammed in Figure 2. Assessment of the attainment of the PEOs is primarily through an annual alumni survey, as described in section 5.2.

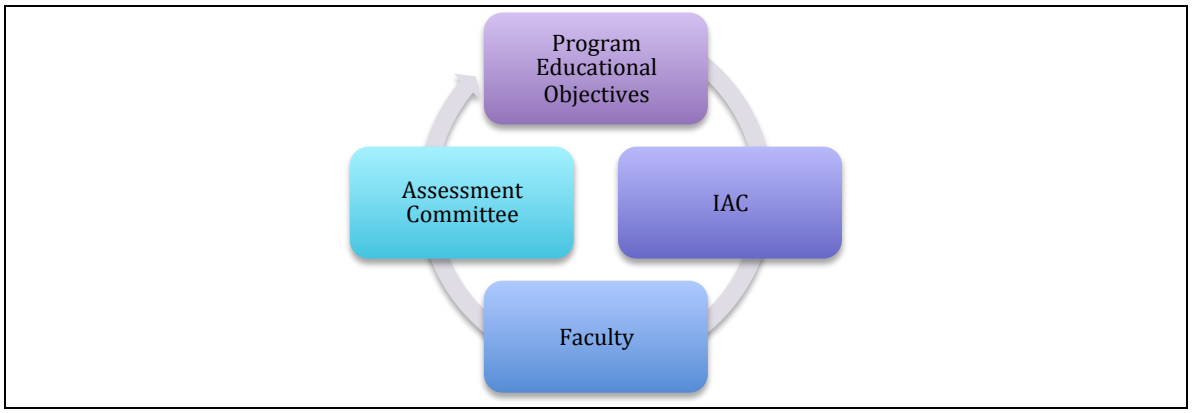

Figure 2. Establishment and modification of Program Educational Objectives.

The objectives are available on the ECE Department web site at:

http://ece.usu.edu/htm/department/assessment/program-objectives

The PEOs also appear in the USU General Catalog.
The PEOs for both programs in the ECE Department are given in the statement below.

PEO 1: Graduates will succeed in pursuing their chosen career path. The primary indicator of success is that graduates will establish a reputation among their peers for engineering expertise and sound ethical judgment. Other indicators of success include:
(a) achieving professional advancement with increasing responsibility;
(b) engaging in technology-based entrepreneurial activities;
(c) engaging in advanced study in engineering graduate programs or related areas.

PEO 2: Graduates will engage in a continuous process of life-long learning. Evidence of such engagement includes activities such as:
(a) staying abreast of emerging technologies;
(b) obtaining new skills or developing proficiencies with tools and programming/hardware description languages;

(c) actively participating in professional communities.

3. Student Outcomes

Student outcomes "describe what students are expected to know and be able to do by the time of graduation. These relate to the skills, knowledge, and behaviors that students acquire as they progress through the program." (Criteria for Accrediting Engineering Programs," ABET 2013-2014.)

The Electrical Engineering Program and the Computer Engineering Program use eleven student outcomes to prepare graduates of the respective program to attach the program educational objectives. The student outcomes are:

(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 within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability
(d) an ability to function on multidisciplinary 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, economic, environmental, 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.

The program educational objectives are two-fold. The first objective is for graduates to succeed in their chosen career paths. The second objective is for graduates to continue learning throughout their lives. Successful attainment of these two objectives relies on a core set of skills, knowledge and behaviors that graduates acquire as they progress through the program. The student outcomes focus on this core. The paragraphs below describe how the student outcomes prepare graduates to attain the program educational objectives.

The first program educational objective (PEO 1) is for graduates to succeed in their chosen career paths, where "success" is defined to be demonstrating engineering expertise and sound ethical judgment. Expert-level engineering knowledge and skills are derived from training and experience. Outcomes (a), (b), (c), (e) and (k) have to do with the development of knowledge, (a) and skills (k) applicable to designing systems

(c), designing and conducting experiments to validate or test systems (b), and to formulating and solving engineering problems (e). Therefore, these outcomes directly support the attainment of PEO 1. In addition, a broad education needed to understand the impact of engineering solutions (h) and a knowledge of contemporary issues (j) are as valuable and needed in engineering practice as are textbook knowledge and skill with the tools of the trade. Therefore outcomes (h) and (j) also directly support PEO 1. And, of course, ongoing success requires adapting to circumstances and technologies as they change, requiring an ability to learn new skills and information, as in outcome (i).

The second indicator of career "success" is demonstrating sound ethical judgment. Many things that are technically feasible may be unethical. Therefore, success in a career must include doing well that which is ethically right. Outcome (f) pertains to professional and ethical responsibility, and supports the attainment of PEO 1.

An essential element in the statement of PEO 1 is peer recognition. Included in the group of "peers" are co-workers, subordinates, management, customers, investors, government regulators, and so on. An ability to communicate effectively (g) is a vital skill to establish the desired reputation among peers. Therefore outcome (g) supports PEO 1. Another essential ingredient in positive peer recognition is the need to work effectively with other engineers having the same or even different backgrounds. Engineering projects of all sizes require the combined work of teams of engineers, each with a unique set of skills, knowledge and experience to contribute. Thus outcome (d), which deals with functioning on multidisciplinary teams is essential to the attainment of PEO 1.

The other indicators of success mentioned in PEO 1 are also supported by the (a) through (k) student outcomes. Professional advancement with increasing responsibility is an indication of trust on the part of management based on repeated demonstration of engineering expertise and the application of sound ethical judgment. Entrepreneurial activities require self-confidence and the confidence of investors. Both of these are built upon a record of successes. Advanced study in graduate programs builds upon a foundation of knowledge and skills obtained in earlier studies. The student outcomes described above that lead to positive peer recognition lead to success in these other areas.

The second program educational objective (PEO 2) is for graduates to engage in a continuous process of life-long learning. PEO 2 is nearly a restatement of student outcome (i), but all the other student outcomes play a role here as well. Learning beyond college and even beyond the years of employment is built upon a foundation of understanding in math and science (a), an ability to apply modern tools (k), and to recognize and formulate and engineering problems (e). An ability to communicate effectively (g) includes the ability to learn from what others have written in books, user manuals, and technical literature. Knowledge of contemporary issues (j) and a broad education (h) are also key to engaging in life-long learning. An excellent way to learn

new material is to perform experiments designed to reveal knowledge. (For example, playing around with a computer language is a great way to learn and internalize its syntax.) So ability in experimentation, as in outcome (b), also contributes to life-long learning.

The discussion above relating PEOs and student learning outcomes is summarized in Table 1.

Table 1. Program educational objectives and student outcomes.

	PEO 1 "Success"	PEO 2 "Life-long learning"
(a) Apply math, sci.	X	X
(b) Conduct exp., data	X	X
(c) Design	X	
(d) Multidisc. teams	X	
(e) Engineering problems	X	X
(f) Professional and ethical	X	
(g) Communicate	X	X
(h) Broad education	X	X
(i) Life-long learning	X	X
(j) Contemporary issues	X	X
(k) Engineering tools	X	X

4. Assessment and Evaluation Processes

Sources of Data

Sources of assessment data include:

1. Course Outcomes and Course Assessment Forms
2. Special Assessments for the Student Outcomes (a) – (k)
3. Senior Exit Survey and Interview
4. Industrial Advisory Committee
5. Alumni Surveys
6. Formal visits with representatives from other departments
7. Other discussions with faculty and students

Of the sources listed above, the first three items are formal mechanisms for measuring student attainment of the student outcomes. The IAC meets regularly to discuss the

operation of the department. Table 3 below gives a summary of these three processes. Detailed descriptions of each assessment process follow the table.

The course assessment forms, filled out by the faculty, can be mapped through the course outcomes back to the student outcomes (a)-(k). However, these are considered to be more indirect measures of achievement. In contrast, the special assessments were specifically designed to provide a direct measure of student achievement of the outcomes.

Course Outcomes and Course Assessment Forms

Every course in the curriculum (both undergraduate and graduate courses) has associated with it a set of course outcomes. Course outcomes are to a course what student outcomes are to a program. Course outcomes are broad statements that describe what students are expected to know and be able to do by the end of the course. These relate to the knowledge, skills, and behaviors that students acquire in a course over the span of a single semester. The course outcomes are listed on the ABET syllabus for each course. These syllabi can be accessed from the ECE Department web site at:

http://ece.usu.edu/htm/courses/undergraduate/undergrad_courses

The course outcomes for a given course are established by the faculty and are approved by the assessment and curriculum committees (as necessary for core classes). Course outcomes help the faculty organize the curriculum and establish the prerequisite structure. Course outcomes communicate to instructors of upper-level courses what students are expected to know upon completion of lower-level courses.

Creation, review, and proposing modifications to course outcomes in required courses (ECE 2250, ECE 2290, ECE 2700, ECE 3410, ECE 3620, ECE 3640, ECE 3710, ECE 3870) is the work of ad hoc committees composed of the faculty members with expertise in the subject matter of the course. Because core required courses are prerequisites for other courses, the course outcomes in core courses require the consensus of the instructors for the course in question and for the courses that follow (parties with a vested interest in the materials covered). In upper-level elective courses, individual instructors can propose modifications to course objectives without the need to consult formally with other faculty. All proposed changes are reviewed by the assessment committee before approval is granted to ensure uniformity across the program.

The course assessment form lists the name of the course, the semester, the instructor name and contains a table listing the course outcomes. There is a column in the table that lists the measurement device used to make the assessment. Examples include homework, exams, quizzes, lab assignments, reports, etc. The last column in the table is for the instructor's assessment. The instructor rates the class as a whole on the

attainment of each outcome. A 0-1-2 scale is used: "0" indicates that the outcome was not generally attained, "1" is used to indicate that the outcome was satisfactory, and "2" implies that the outcome was attained beyond a minimal level. A "1" would signal that the outcome was attained but that greater attention to that outcome may be desirable next time the course is taught. When instructors are preparing to teach a course, they are encouraged to review the course assessment form from prior semesters and to consider previous outcomes in their preparations.

The course assessment form also asks instructors to respond to the following three open-ended questions.

1. "How well were students prepared for the course?" – This question aims to collect information relating to the achievement of course outcomes in prerequisite courses.
2. "List significant issues from student evaluations?" – Student course evaluations are conducted for all courses using an on-line system (IDEA). These evaluations contain quantitative and qualitative information on student responses. Instructors are asked to review the student evaluations and record any emergent themes.
3. "Discussion?" – Instructors are asked to record observations about those parts of the course that worked well or need improvement. Instructors should address issues raised in student evaluations. Instructors can recommend changes needed in the course or in prerequisite courses. This has been helpful as a location to record notes to improve the course the next time it is taught, such as where greater emphasis is needed, where the development can be accelerated, etc.

Each course in the department is assessed by the instructor at the end of each semester in which the course is taught. Instructors complete their assessments by filling out the course assessment form. Course assessment forms are turned in to a departmental staff assistant for long-term archiving. The Assessment committee chair reviews all of the course assessments each semester. Issues are taken to the assessment committee for discussion and action. This process has generated a wealth of information for evaluation and continuous improvement. This process has identified problems in prerequisite courses, needed curricular changes, and resource needs. Issues that arise during this process are documented in the departmental annual assessment report.

The numeric data (0-1-2 scale) on the course assessment forms indicate the degree to which students attained the course objectives. Each course supports one or more of the (a)-(k) Student Outcomes as described in the Course-to-Outcome Map in Table 4. Therefore the course assessments provide an indirect measure of the attainment of the Student Outcomes.

Course-to-Outcome Map

The course-to-outcome map (the "map") is a table Table 4 listing both required and elective courses in the Electrical Engineering Program. The map consists of a column for

each of the (a) through (k) student outcomes. The 0-1-2 entries in the table indicate how strongly courses support the attainment of the outcomes, with "2" indicating strong support, "1" indicating weak support, and "0" indicating no support. Analysis of the map indicates that all of the outcomes are strongly supported at some point in the curriculum. The course-to-outcome map is updated when courses are added to the curriculum. The map is also useful as a tool to analyze how adjustments to the curriculum affect the way that the curriculum supports the attainment of student outcomes. For example, if deleting a course will result in a gap, this is most easily determined by an inspection of the course-to-outcome map. Therefore, this map provides a tool to help manage both curriculum and assessment processes.

Special Assessments for Student Outcomes (a)-(k)

By means of the mapping from courses to student outcomes, course assessment forms provide an indication of the attainment of the student outcomes by the students in the program generally. In addition, direct measures of attainment of the student outcomes for each student in the program are provided by special assessments.

Special assessments are designed to assess all students in a program on each of the student outcomes (a) – (k). To achieve this objective, these assessments are implanted into the curriculum in the core, required courses and are attached to specific projects, reports or assignments in these courses. Table 4-3 shows the assignment of student outcomes to courses in the core curriculum. Since these are courses in the "core," these classes are taken by both the electrical engineering majors and the computer engineering majors. These assignments were developed by the department head and the chairs of the assessment and curriculum committees and are periodically reviewed by them.

Table 2. Special Assessment Course Assignments.

Student Outcome	Course	Semester
(a)	ECE 3620 - Continuous Time Signals & Systems	Fall
(b)	ECE 3640 - Discrete-Time Signals and Systems	Spring
(c)	ECE 4840 - Engineering Design II	Fall/Spring
	ECE 4850 - Engineering Communications II	Fall/Spring
(d)	ECE 4840 - Engineering Design II	Fall/Spring
(e)	ECE 3710 - Microcomputer HW/SW	Spring
	ECE 4850 - Engineering Communications II	Fall/Spring
(f)	ECE 3810 – Engineering Professionalism	Fall/Spring
(g)	ECE 4840 - Engineering Design II	Fall/Spring
	ECE 4850 - Engineering Communications II	Fall/Spring
(h)	ECE 4840 - Engineering Design II	Fall/Spring

	ECE 4850 - Engineering Communications II	Fall/Spring
(i)	ECE 4840 - Engineering Design II	Fall/Spring
(j)	ECE 4840 - Engineering Design II	Fall/Spring
(k)	ECE 3410 - Microelectronics	Spring

Instructors of courses where a special assessment is assigned have some flexibility to choose the specific student assignment used for the special assessment. The assessment committee chair meets with each instructor prior to the start of the semester to discuss the special assessment process. The assessment chair and a departmental staff assistant make sure that the special assessments are completed during the semester and that appropriate documentation is turned in for archival purposes. Feedback from instructors and changes to special assessments are taken back to the department head for discussion. The main points from these discussions are documented in the departmental annual assessment report. Examples of specific student assignments that relate to the (a)-(k) student outcomes are listed below.

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

- ECE 3620 – Computer programming assignment on numerical solution to differential equations: the zero-input solution.

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

- ECE 3640 - Computer programming assignment on finding the maximum step-size for an adaptive filter that maintains filter stability.

Student Outcome (c) - an ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability

- The reports generated as described in Table above for stages of the senior project design.

Student Outcome (d) - an ability to function on multidisciplinary teams

- ECE 3810 - Students complete a project design as a team and are graded as a team. Teams may contain both EE and CE majors (and are, to that extent, somewhat multidisciplinary). Teaming is scored based on design review in ECE 3810 and all design documentation.
- There are questions about working on teams on the senior exit questionnaire and in the senior exit interview, in which the computer engineers and electrical engineers are evaluated separately.

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

- ECE 3710 - Project assignment on design of a security system for a room using an array of sensors with different timing specifications and outputs.

Student Outcome (f) - an understanding of professional and ethical responsibility

- ENGL 3080 contains a unit on ethics.
- ECE 3810 contains formal presentations and teaching about ethics and professional responsibility. Written examination on ethical questions.
- There are questions about ethics on the senior exit questionnaire and in the senior exit interview.

Student Outcome (g) - an ability to communicate effectively

- ENGL 3080, ECE 3810, and ECE 4850 - Students turn in an extensive amount of written work.
- The senior project preliminary design review, critical design review, and final design documents are examples of student written work.
- The senior project presentation gives students the opportunity for oral communication.

Student Outcome (h) - the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context

- ECE 4840/4850 - In the senior design document students describe the impact of their project in a global, economic, environmental, and societal context
- ECE 3810 contains formal presentations and teaching about these elements.
- There are questions about broad education on the senior exit questionnaire and in the senior exit interview.

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

- ECE 3810 - Students have learning modules in class with written evaluation questions.

Student Outcome (j) - a knowledge of contemporary issues

- ECE 3810 - Discussions, with written examination.

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

- ECE 3410 - Laboratory assignment on analysis, simulation, and measurement of MOSFET amplifiers

Some of the special assessments have specific forms associated with them. Other special assessments use the graded, turned-in student work itself as the documented evidence. When specific forms are used, the instructor or the TA fills out the form while grading the student work and scores student attainment on a 0-1-2 scale. The form is

retained and placed in an archive, and the student's work is returned to the student. In addition a staff assistant enters student attainment scores in a spreadsheet so that average levels of student attainment can be computed on a per outcome basis.

Senior Exit Survey and Interviews

Each graduating senior is asked to complete a senior exit survey. The survey includes questions about the program including the different areas of the curriculum, the pre-professional program (math, science, computer science), general education, and so on. The survey also asks students to evaluate their own knowledge and abilities on a 1-5 scale in the areas of the 11 student outcomes. While this survey does not measure their attainment, it measures the degree to which students perceive they have attained the student outcomes.

After completing the senior exit survey, the graduating seniors are invited to a luncheon with the department head and the chairs of the curriculum and assessment committees. During the luncheon, students are invited to respond openly about strengths and weaknesses of the program, the curriculum and its prerequisite structure, labs and facilities, the instructors, technical support, and so on. Students are specifically asked about the eleven student outcomes (a)-(k). An administrative staff assistant is present to capture and type student responses.

The senior exit survey and interview provide valuable inputs to the assessment process. Often themes emerge that are taken back to the curriculum and assessment committees for further discussion. These themes are documented in the annual assessment report.

Alumni Survey

Each year surveys are sent to alumni five years after their graduation date. The survey contains approximately 20 questions designed to measure alumni perception of their attainment in areas related to the student outcomes and program objectives. Many questions require a response on a five-point scale where 5 corresponds to a strong positive response or agreement and 1 corresponds to a strong negative response or disagreement.

Summary

For the annual assessment, the following sources of information are used:

- Input from the industrial advisory committee
- Interview summaries from the senior exit interviews and senior exit survey
- Alumni surveys
- Course assessment forms

- Input from (a)–(k) special assessment forms and devices

Once the faculty course assessments are collected, they are reviewed by the department assessment committee, along with alumni surveys, student exit interview summaries, input from the IAC and from employers, and input from department meetings. From this review, the chair of the assessment committee writes an annual assessment report. This report includes information such as the following:

- Results and changes made during the year are summarized
- Curricular and assessment goals for the upcoming year
- Issues needing discussion in faculty meeting affecting the curriculum as a whole
- Issues from particular classes determined from the faculty course assessments that rise to the level of departmental concern

This report is reviewed by the assessment committee. It is then circulated among the faculty and discussed at the annual Fall departmental retreat. The faculty, then, take input from the annual assessment report to incorporate into their teaching.

The overall result of this process is that the curriculum is fairly cohesive and flows well. There are, in reality, some issues still to be worked out. But the assessment process has brought attention to these issues, and motivates the need to resolve these concerns. The inclusion of ABET (a)-(k) outcome measurements keeps focus on points that must be covered well and ensures that all students receive the coverage they need on all aspects.

Table 3. Assessment Processes.

Process			
Course Assessment Form	One form for each course. Form lists the course outcomes. Form filled out by instructor. Assesses general attainment of course outcomes.	Completed each time a course is taught.	On a 0-1-2 scale, attainment of a 2 score is expected in each course outcome. A 2 indicates that attainment of the course outcome by the students in the course is satisfactory.
Special Assessment for Student Outcome (a)	One form for each student. Associated with a specific homework assignment in ECE 3620. Form filled out by the TA. Assesses student attainment of Student Outcome (a).	Completed each time ECE 3620 is taught.	On a 0-1-2 scale, attainment of a 2 score is expected. A 2 indicates that the student demonstrated ability to apply math, science and engineering.
Special Assessment for Student Outcome (b)	One form for each student. Associated with a specific homework assignment in ECE 3640. Form filled out by the TA. Assesses student attainment of Student Outcome (a).	Completed each time ECE 3640 is taught.	On a 0-1-2 scale, attainment of a 2 score is expected. A 2 indicates that the student demonstrated ability to design and conduct experiments and analyze and interpret data.
Special Assessment for Student Outcome (c)	Students produce a specification document. Students produce initial design. Students produce a preliminary design review. Students produce a critical design review. Students demonstrate their design projects. Students produce a final design report. Reviewed by ECE faculty for technical content, and by English department associate for writing.	In ECE 4830 and ECE 4850. Each are taught every semester (students take one semester of each).	Students recognize and define functional requirements; recognize and define nonfunctional requirements (e.g., environment, hardware, power, etc.); recognize and define design constraints. Evaluated in step (3). Demonstration of technical competence; opportunity to critique initial design. Demonstrate that they have addressed concerns raised in PDR and complete anything not finished for the PDR. Demonstrate ability to interact with public (e.g., external reviewers); demonstrate visual communication ability. Assemble the complete documentation of project, including testing data.
Special Assessment for Student Outcome (d)	Project design package completed by student teams. Mirrors steps 1 and 2 of the outcome C design steps.	Completed each time ECE 3810 is taught.	Mirrors steps 1 and 2 of the Outcome C design steps.

Special Assessment for Student Outcome (e)	One form for each student. Associated with a specific homework assignment in ECE 3710. Form filled out by the TA. Assesses student attainment of Student Outcome (e).	Completed each time ECE 3710 is taught.	On a 0-1-2 scale, attainment of a 2 score is expected. A 2 indicates that the student demonstrated ability to identify, formulate, and solve engineering problems.
Special Assessment for Student Outcome (f)	Weekly written responses to ethics questions during the ethics module in ECE 3810.	Students study a three-week ethics module in ECE 3810, with ethics case studies.	Demonstration of thinking about ethical questions students may encounter during their careers.
Special Assessment for Student Outcome (g)	Work written by and presented by students.	Completed each time ECE 3810 and ECE 4850 are taught.	Both classes involve written and verbal communication. Demonstrated on requirements document and design review documents and presentations.
Special Assessment for Student Outcome (h)	Senior design documents, in project proposal and final project report. Technical content evaluated by ECE faculty, writing content by English department associate.	Completed each time ECE 4840/4850 are taught.	Clear writing and a demonstration of impact of their project in a larger context.
Special Assessment for Student Outcome (i)	A question evaluating students' understanding of the necessity of lifelong learning.	Completed each time ECE 3810 is taught in a short module.	Clear writing and a demonstration of student's understanding.
Special Assessment for Student Outcome (j)	Students answer written questions.	Each time ECE 3810 is taught. Students learn about workplace environment, harassment, and globalization.	Clear writing and a demonstration of student's understanding.
Special Assessment for Student Outcome (k)	One form for each student. Associated with a specific homework assignment in ECE 3410. Form filled out by the TA. Assesses student attainment of Student Outcome (k).	Completed each time ECE 3410 is taught.	On a 0-1-2 scale, attainment of a 2 score is expected. A 2 indicates that the student demonstrated competence in student outcome (k) on the assignment.

Senior Exit Survey and Interview	Survey completed by graduating seniors.	Completed each December and April prior to graduation.	On a 0-5 scale, students evaluate their attainment of the student outcomes (a)-(k).

Table 4. Course to student outcome map. Shading indicates core courses.

	Student Outcomes										
Course Number and Name	**a**	**b**	**c**	**d**	**e**	**f**	**g**	**h**	**i**	**j**	**k**
ECE 2250 – Electrical Circuits 1	2	2	1	0	1	1	1	0	0	0	1
ECE 2290 – Electrical Circuits 2	2	2	1	0	1	1	1	0	0	0	1
ECE 2700 – Digital Circuits	2	2	2	0	1	0	0	0	0	1	2
ECE 3410 – Microelectronics I	2	1	2	0	2	0	1	0	0	0	2
ECE 3620 – Continuous-Time Sys. and Signals	2	2	1	0	2	0	0	0	0	0	2
ECE 3640 – Discrete-Time Systems and Signals	2	2	0	0	2	0	0	0	0	0	2
ECE 3710 – Microcontroller HW/SW	2	1	2	1	2	0	2	0	1	0	2
ECE 3810 – Engineering Professionalism	1	2	2	2	1	2	2	2	2	2	1
ECE 3870 – Electromagnetics I	2	2	1	0	2	1	0	0	0	1	1
ECE 4820 – Engineering Design I	1	1	2	2	2	2	2	1	1	1	0
ECE 4830 – Engineering Communications I	1	1	2	2	2	2	2	1	1	1	0
ECE 4840 – Engineering Design II	0	0	0	1	0	1	2	1	0	0	1
ECE 4850 – Engineering Communications II	0	0	0	1	0	1	2	1	0	0	1
ECE 4250 – Internship / Co-op	1	1	1	2	1	2	2	2	2	2	2
ECE 5140 – Electrical Energy Engineering	2	2	2	2	2	1	2	1	1	1	2
ECE 5220 – Electro-optical Engineering	2	2	2	2	2	1	2	1	1	1	2
ECE 5230 – Spacecraft Systems Engineering	2	1	2	1	2	1	1	1	0	0	1
ECE 5240 – Space System Design	1	1	2	2	2	1	2	1	1	0	1
ECE 5310 – Control Systems	2	2	2	1	2	0	0	0	0	0	2
ECE 5320 – Mechatronics	2	1	2	1	2	0	1	0	0	0	1
ECE 5340 – Mobile Robots	1	1	2	1	2	0	0	0	0	0	1
ECE 5410 – Semiconductor Devices	2	0	0	0	1	0	1	0	0	1	2
ECE 5420 – Microelectronics II	2	1	2	0	2	0	1	0	0	0	2
ECE 5440 – Analog VLSI I	1	1	2	0	1	0	1	0	0	0	2
ECE 5460 – VLSI Design Automation	1	2	2	0	2	1	1	0	0	0	2
ECE 5470 – VLSI Design	1	2	2	0	2	1	1	0	0	0	2
ECE 5600 – Introduction to Computer Networks	2	2	2	1	2	1	2	2	2	2	2
ECE 5630 – Digital Signal and Image Processing	2	2	1	0	2	0	0	0	0	0	2
ECE 5640 – Real-Time Processors	1	2	2	0	2	0	1	1	1	0	2
ECE 5660 – Communication Systems I	2	0	2	0	2	0	0	0	0	0	2
ECE 5680 – Transceiver Systems Engineering	2	0	2	1	2	0	0	0	0	0	2
ECE 5700 – Introduction to Microfabrication	2	1	2	0	2	0	0	0	0	0	1
ECE 5720 – Computer Systems Prog and Arch.	2	2	2	1	2	1	1	1	2	1	2
ECE 5750 – Computer Architecture	2	2	2	0	2	1	1	1	2	1	2
ECE 5770 – Microcomputer Interfacing	2	2	2	0	2	0	1	0	1	0	2
ECE 5780 – Real-Time Systems	2	2	2	0	2	0	1	1	2	1	2
ECE 5800 – Electromagnetics II	2	1	0	0	2	0	1	0	1	1	2
ECE 5810 – Microwaves I	2	2	2	1	2	0	0	1	1	1	2
ECE 5850 – Antennas I	1	2	2	1	1	1	1	1	1	2	2
ECE 5930 – Introduction to Power Electronics	2	1	2	0	1	0	1	0	1	1	2
ECE 5930 – Computer Security	2	2	1	1	0	1	1	0	1	1	2
ECE 5930 – Advanced Electrical Energy	2	2	2	1	2	2	2	1	1	1	2