Session 2532

Process to Identify Minimum Passing Criteria and Objective Evidence in Support of ABET EC2000 Criteria Fulfillment

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Abstract

This paper describes a methodology for combining course assignments that summarize course objectives with grading policy to ensure fulfillment of EC2000 criteria. The methodology involves the development of a grading policy that includes using key assignments that represent course material that strongly represents the course objectives and using these assignments to define 'minimum passing criteria'. The grading policy insures that no student passes the course without demonstrating competence in all course objectives. Also, these key assignments become the objective evidence for the course meeting its program/EC2000 criteria. The result is a methodology that defines specific assignments to assess student learning outcomes and objective evidence of each student having meet course and program outcomes.

Introduction

The Department of Electrical and Computer Engineering at Gannon University was challenged by their industrial constituents to correlate passing criteria with course objectives. To meet this challenge, the ECE department has developed a process to help faculty systematically identify *minimum passing criteria* associated with course learning outcomes. Minimum passing criteria measure student performance for specified course outcomes, thus ensuring that any student passing a course has met the minimum course objectives. This assurance further allows the department to systematically justify that a successful graduate will meet the program criteria. The process includes the identification of minimum passing criteria, also a method to identify the necessary objective evidence in supporting the criteria fulfillment.

The department has recently completed a major effort in restructuring and refining its departmental goals and objectives, catalog, and operations in preparation for its next EC2000 criteria-based ABET visitation. This effort includes consistent communication and measurement of department outcomes. As part of the process, the analyzed results were reported to one of the constituents – the external/industrial members from engineering employers in the region. The major feedback from the industrial members was to have the department develop a quantifiable process that identifies objective evidence to support all claims made, and ensure that passing students actually meet the stated program criteria. Based on these suggestions and feedback, the department has successfully designed a process to address these needs. This process has been piloted within two senior-level courses, power electronics and senior design, to test out the process and evaluate the effort.

The process involves criteria identification, course objectives correlation, key assignment identification, minimum passing criteria justification, objective evidence documentation. The paper describes the process in detail and provides examples to illustrate the process applied. The paper also addresses the lesson learned from implementing the minimum passing criteria in class and suggests a systematically way to justify that all successful graduates will also meet the program criteria in general.

To better illustrate the concept involved in the establishing the minimum passing criteria, we will first give brief discussion to the assessment processes that are currently in place. Next, the correlation of course objectives to the program outcomes is given to further illustrate assessing course objectives is a necessary condition, but may not be sufficient. To further achieve a necessary and sufficient condition in claiming meeting course objectives is in turn meeting program outcomes, we then give and discuss the process in establishing the minimum passing criteria.

ECE program assessment process

The ECE department program assessment process begins with the university mission. The university mission in turn impacts the department goals. The program outcomes are derived and judged based on the ABET criteria [1] and the IEEE department specific criteria as well as our department specific competencies. With these in mind, each course objective and assessment method is carefully examined for a better coordination among courses and setup in order to reach a complete coverage of the program outcomes that lead to achieving the program goals.

The correlation between all required electrical engineering courses begins with the individual course's objectives to the program outcomes. The correlation between program outcomes and program objectives will be explained in detail in the next section. Using the correlation relationship between program objectives and the program outcomes, each course objective is then mapped to the program objective accordingly. With this correlation relationship in place, we focus then on the assessment of each course's objectives meeting the program outcomes. By having all courses meeting the program outcomes, the program objectives are in turn met accordingly.

The assessment of these curriculums takes multiple forms. Ref [2] gives very good examples on a variety of learning assessment tools. In our case, most of the tools used to assess strategies and outcomes are also important in establishing the curriculum success in meeting program educational objectives. Evaluation tools include interviews with graduating seniors, course surveys, surveys with employers of our co-op students, and feedback from the industrial members committee. The input that we receive from these assessment processes is fed back to the faculty for discussion and action items generation. The action items then drive the changes in the program, the curriculum, and the assessment process itself.

Program outcomes and program educational objectives relationship

To better illustrate the process that we use to ensure program curriculum meeting the program educational objectives, let's first identify the program outcomes in which the curriculum are to measure and the relationships of these program outcomes to the program educational objectives. The program objectives are:

Pgm Obj 1. Sound preparation for adaptation in exciting, rapidly-changing areas of technology and the passion for lifelong learning

Pgm Obj 2. Ability to respond to ethical and public issues, including safety, social, environmental concerns, and understanding of how engineering solutions affect the wider society

Pgm Obj 3. Ability to apply personal values to daily and professional life, the development of skills necessary for exercising informed literary and aesthetic judgments, and a development of an appreciation of diverse cultures and societies.

Pgm Obj 4. Foundation in problem formulation and problem solving skills to include the following:

- Sound preparation in general science and applied mathematics
- Strong electrical engineering and applications.
- Strong computer and software systems development
- Effective use of computer-aided design & analysis tools.
- Quality engineering design experience

Pgm Obj 5. Ability to communicate effectively in both oral and written forms, and skills for effective work within multi-disciplinary teams which foster leadership qualities

Table 1 defines the correlation that exists between the program objectives and the program outcomes. Our department has adopted the ABET (a) –(k) as part of the program outcomes. We added three department specific competencies that derive from the IEEE program criteria. Faculty went through a series of discussions to identify and correlate these outcomes with the program objectives.

Table 1 Correlation between program educational objectives and the program outcomes

	Pgm Obj 1	Pgm Obj 2	Pgm Obj 3	Pgm Obj 4	Pgm Obj 5
ABET Criteria:					
A) Apply knowledge of Mathematics, Science, and Engineering	X			X	
B) Ability to design and conduct experiments; Analyze and interpret data				X	
C) Design system, component, or process to meet needs	X			X	
D) Function on multi-disciplinary teams			X		X
E) Identify, formulate, and solve engineering problems	X			X	
F) Understanding of professional and ethical responsibility		X	X		

G) Ability to communicate effectively			X		X
H) Broad education necessary to understand impact of engineering solutions	X	X	X		X
I) Recognition of need to engage in lifetime learning	X		X		
J) Knowledge of contemporary issues	X		X		X
K) Ability to use techniques, skills and modern tools	X			X	
ECE Department specific Competencies:					
1) Knowledge and ability to apply mathematics including probability, statistics, and discrete mathematics	X			X	
2) Develop systems containing hardware & software components	X			X	
3) A&D of Complex electrical & Electronic Devices	X			X	

Based on the correlations defined and reviewed in the outcomes process, Table 1 clearly indicates the full encompassment of the program outcomes to each of the program educational objectives. As the program is built upon a specific set of courses, the key assessment question is how to measure the effectiveness of the courses that constitute the program in helping students achieve the program objectives and the program outcomes.

Processes used to assess each of the program outcomes

The electrical engineering curriculum and the steps taken to effectively implement the curriculum are the main vehicles that ensure the program outcomes (ABET criteria and department specific competencies) are met. Because of the importance of curriculum in meeting the criteria, the faculty regularly update a curriculum matrix to describe how each of the course objectives for all required courses relates to the program outcomes.

The ECE department maintains a curriculum matrix that gives the overall view of correlation between ECE courses and the corresponding program outcomes. The curriculum matrix is in fact a collective overview of a more detailed curriculum matrix that relates each course's student learning objectives to the program outcomes. The overall curriculum matrix is maintained on-line, and is updated each semester when faculty enter their course objectives on-line [3, 4]. This process is part of a course-exit survey system [3], and includes faculty entering portions of their syllabus online. Figure 1 illustrates the objectives correlation of course objectives to the program outcomes for one course.

	ABET Criteria											Department Specific Competencies		
Department courses with objectives	A	B	C	D	E	F	G	H	I	J	K	1	2	3
ECE465 Power Electronics														
Objective 1	X				X									X
Objective 2		X												
Objective 3											X			
Next ECE course														

Figure 1 Partial curriculum matrix mapping course objectives to program outcomes

As part of the department's assessment processes, the overall curriculum matrix is reviewed at the end of the semester along with the prior semester's survey data at a special faculty meeting. The matrix provides information on overall program evaluation and completeness. It also serves as a basis for illustrating how the courses that constitute the program collectively meet the program outcomes defined in Table 1.

As part of the assessment improvement process, this curriculum matrix was presented to an industrial members committee on July 18 and July 29, 2003 respectively. This committee was asked to assess the program for its effectiveness in meeting the program educational objectives. After reviewing the information provided in complete curriculum matrix and supporting materials, the committee was convinced that the *program* looked effective, and would achieve the stated outcomes. However, the key result of these meetings was that the ECE department was challenged to enhance the process *to ensure that* each *student going through the program will meet* all *the criteria* as well.

Comments were that the program would in fact achieve its goals on assessment if it could ensure that all students who pass a course will also meet that particular course's objectives as a minimum passing criterion. In other words, what we had done thus far focused on the average student in the program, with the result that a student could graduate without having demonstrated competence in one or more key areas. Some forms of course-specific judging criteria were suggested to determine our success in meeting the course objectives, and thus confirm that each student who graduates meets the program goals. From this concern, we were challenged by the industrial members committee to device a process to focus the program assessment more clearly on student learning outcomes assessment.

From these observations, the department devised a process for mapping course objectives to the program outcomes that leads to defining the minimum grading policy. The point was to ensure that upon passing a class, all students can be assured of (at least minimally) meeting the course objectives. The result of this process is that once faculty establish the minimum criteria necessary to ensure that all students passing a course indeed meet the stated course objectives. The program can safely assure the validity and effectiveness of the correlation between the program outcomes and the program educational objectives. As a by-product of the minimum passing criteria process, faculty are immediately provided with straightforward method for determining useful objective evidence in support of meeting course objectives.

To evaluate the proposed minimum passing criteria process, two courses were selected in the Fall 2003 semester for a pilot implementation: ECE465 Power Electronics and ECE357 Senior Design. The plan was to review the effectiveness and effects of this new assessment process before a full-scale implementation is pursued. The following section illustrates this new mapping process as it was applied to the ECE465 Power Electronics course in the Fall 2003 semester.

Sample procedure to identify minimum passing criteria and objective evidence

The following list illustrates the process adopted to address the concern raised by the industrial constituents, and summarizes how the criteria mapping procedure was accomplished for this course, ECE465 as an example.

Step 1: Faculty list identified course objectives. Since these course objectives were already approved by the department, no additional work was necessary.

Step 2: Faculty identify the program outcomes (ABET criteria and departmental competencies) satisfied by this course and the correlation to the course objectives. For example, course objective 2--- *Develop skills in using contemporary software tools for modeling and its analysis* as an illustrative example. This particular course objective was mapped to the program outcome --- *Ability to use technique, skills, and modern tools*. Please see Figure 2a.

Step 3: Faculty must understand the judging/grading criteria for this particular course objective. In this case, in order to satisfy course objective 2, the criteria must have component in *ability to use technique, skills, and modern tools.*

Step 4: Faculty list the planned (typically major) assignments in the class and identify key assignments that support this course objective 2. For this class, there are 6 projects, 2 experiments, and a final project. To satisfy course objective 2, part A of the final project was picked as the key assignment for judging in meeting the criteria. Justification for picking this particular set of assignment is explained in the mapping process and is later documented in the formal syllabus as well. Faculty are free to pick as few or as many key assignments as they wish as long as they are well justified, as this is a key item of review for the syllabus.

Step 5: The passing grade in assessing the success in meeting the criteria is a grade of C for this class. During the review of this syllabus, the department agreed that passing these key assignments with a grade of C is in general an acceptable grade for meeting the course objectives.

Step 6: Faculty summarize the objective evidence needed for documenting the effectiveness of the class. Figure 2 shows the final syllabus that documents the passing criteria and the corresponding objective evidence for this class. By following this process, it is very clear that what objective evidences are needed to collect at the end of the semester for each course as well as the justification for the objective evidence.

Step 7: The syllabus was reviewed with the department faculty.

These steps were used to determine the minimum passing criteria and objective evidence for both Fall 2003 pilot courses. This information, once determined, was then integrated into the course syllabus. One pilot course, ECE 465 *Power Electronics,* is used here to illustrate the process. Figures 2a and 2b show the complete criteria mapping template filled in with the details of the ECE 465 *Power Electronics* course.

Criteria Mapping Process

Step 1: Define Course Objectives:

Course Objectives:

1. Understand the fundamental principles on various power converter topologies, design of power converter, and the related performance analysis.
2. Develop skills in using contemporary software tools for modeling and its analysis.
3. Develop skills in construction and parameter measurement of converters.

Step 2: Define ABET Criteria Fulfillment Satisfied and Map Course Objectives Accordingly:

Criteria Fulfillment Satisfied:

Course objectives

ABET criteria

- Foundation in applied math --- objective 1
- Conduct Experiment --- objective 3
- Analyze & interpret experimental data --- objective 3
- Formulate engineering problem --- objective 1
- Solve engineering problem --- objective 1
- Ability to use technique, skills, and modern tools --- objective 2
- A&D of complex electrical & electronics systems --- objective 1

Step 3: Understand Judging/Grading Criteria in Meeting Objectives:

Passing Objective Criteria:

- **Understand the fundamental principles on various power converter topologies, design of power converter, and the related performance analysis**
  Must have components in *foundation in applied math, formulate eng problem, solve eng problem, A&D of complex electrical & electronics systems*
- **Develop skills in using contemporary software tools for modeling and its analysis**
  Must have components in *ability to use technique, skills, and modern tools*
- **Develop skills in construction and parameter measurement of converters**.
  Must have components in *conduct exp, analyze & interpret exp*

Step 4: Examine All Assignments and Identify Key Assignments:

Projects & Homework sets:

Proj1: 1-phase diode bridge rectifier
Proj2: Basic concepts in thyristor converters
Proj3: 3-phase half-controlled bridge rectifiers
Proj4: Rectifier applications
Proj5: Dc-dc Buck converter
Proj6: Dc-dc converter applications
Final Proj: Control of Electric Drive
Exp1: Controlled rectifier
Exp2: dc-dc converter applications

Figure 2a Criteria mapping procedure steps 1-4

Step 5: Define Minimum Necessary Passing Grading Policy:

Necessary Passing Grading Policy against criteria/objectives:

- **Understand the fundamental principles on various power converter topologies, design of power converter, and the related performance analysis**
  Must have components in foundation *in applied math, formulate eng problem, solve eng problem*:
    Proj5 (passed with a grade of C or better)
    Projs 1 thru 6 cover various aspects of the power converter topologies, design, and performance analysis. Proj 5 requires student to design a converter against criteria given and simulate to verify the design. Hence it is used as a gauge to "foundation in applied math", "formulate eng problem" and "solve eng problem"
  A&D of complex electrical & electronics systems:
    Final Proj (must complete part A of final) --- Part A requires A&D of an inverter design. Part B includes the design of filter and integration of a front-end converter. Completion of part A (grade C or better) indicates the acquired skill.

- **Develop skills in using contemporary software tools for modeling and its analysis**
  Must have components in *ability to use technique, skills, and modern tools*:
    Final Proj (must complete part A of final) --- part A of final requires student to apply software skills learned in the course independently in analysis and design of the problem. Complete part A correctly (grade C or better) indicates the needed skills have been acquired accordingly.

- **Develop skills in construction and parameter measurement of converters**.
  Must have components in conduct *exp, analyze & interpret exp*:
    Exp 1 short report, Exp2 short-report (combined average of C or better)
    Short reports are accepted only after the corresponding experiment has been conducted. Data are required to be analyzed accordingly.

Step 6: Finalize Objective Evidence for Meeting Course Objectives:

Objective Evidence:

- Foundation in applied math --- objective 1 --- Proj 5
- Conduct Experiment ---objective 3 --- Exp 1 and 2
- Analyze & interpret experimental data --- objective 3 --- Exp1 and 2
- Formulate engineering problem ---objective 1 --- Proj 5
- Solve engineering problem ---objective 1 --- Proj 5
- Ability to use technique, skills, and modern tools ---objective 2 --- Final Proj
- A&D of complex electrical & electronics systems --- objective 1 --- Final Proj

Step 7: Rework your Syllabus ---
Filter in your New Minimum Passing Grading Policy, Key Assignments, Objective Evidences:

Figure 2b Criteria mapping procedure steps 5-7

The first six steps lead the instructor to a clear definition of the key assignments, criteria mapping, and objective evidence for this instance of the course. Step seven of the procedure is where this information is then translated to the course syllabus for communication to the students. Following the steps shown in Figures 2a and 2b, the following syllabus was created, and used in the ECE 465 Power Electronics class during the Fall, 2003 Semester. The completed syllabus is presented in Figure 3 below.

------------------------------------ECE 465 Power Electronics Syllabus ----------------------------------

Instructor:	Fong Mak
Office:	Zurn 303
Office Hours:	Tuesday and Thursday, 10am – noon
Contact Info:	mak@gannon.edu; 871-7625
Class Location:	Z331A
Time:	Tuesday and Thursday 4:30pm – 5:50pm

ECE465 Power Electronics
Fall Semester 2003

Course Description:
This course introduces the basic concepts of various topologies (ac-dc, dc-dc, dc-ac, ac-ac, etc) of power converters. The fundamental principles of switching components are discussed first prior to introduction of the design and application of the converters. Emphasis is on the design issues associated with the converters and the computer techniques (OrCAD) used for the performance evaluation and analysis. Experiments are part of the course.

Prerequisites*:* ECE333 or ECE324
Course Objectives:
1. Understand the fundamental principles on various power converter topologies, design of power converter, and the related performance analysis.
2. Develop skills in using contemporary software tools for modeling and its analysis.
3. Develop skills in the construction and parameter measurement of converters.

Criteria Fulfillment Satisfied:
- Foundation in applied math ---objective 1
- Conduct Experiment ---obj3
- Analyze & interpret experimental data ---obj3
- Formulate engineering problem ---objective 1
- Solve engineering problem ---obj1
- Ability to use technique, skills, and modern tools ---obj2
- A&D of complex electrical & electronics systems ---obj1

Step 2 info entered here

Course Outline:

Group	Topics	Units
A) Basic concepts in switching converters	Goals and Methods of Electrical Conversion	Chap 1
	Review of Fourier Series	Appendix E
	Power Semiconductors	Chap 2
	Homework or projects	Class notes
B) AC-DC Converter	Diode Circuits	Chap 3
	Rectifier	Appendix D
	Thyristor	Chap 7
	Controlled Rectifier	Chap 10
	Lab work, projects	Class notes
	Mid Term	
C) DC-DC Converter	Power Transistor	Chap 4
	DC-DC Converter	Chap 5
	Lab work, projects	Class notes
D) DC-AC Converter	Various PWM controls, voltage control, dc link, inverter, etc.	Chap 6 Class of notes
	Homework or projects	
E) AC-AC Converter	Combined converters for specific application, etc.	Chap 11 Class notes
	Final Exam or Project	

Course Assessment Methods:

Assessment Methods	Objective 1	Objective 2	Objective 3
Graded Homework	X	X	
Examinations	X	X	
Projects	X	X	
Lab Work			X

Course Assessment Method Details:

Homework:
Homework problems shall be designed to test knowledge and comprehension in power electronics design issues and analysis.

Expected Homework Projects:

Proj 1: 1-phase diode bridge rectifier
Proj2: Basic concepts in thyristor converters
Proj3: 3-phase half-controlled bridge rectifiers
Proj4: Rectifier applications
Proj5: DC-DC Buck converter
Proj6: DC-DC converter applications

Step 4 info entered here

Examinations:
The exam shall contain problems designed to test knowledge and comprehension in power electronics design issues and analysis.

Expected Examinations:

Mid Term Examination and possibly a Final Examination

Project:
The project shall be designed to give more than one way to meet the problem requirements and to utilize software tools in aid of design. A documented outcomes and/or demonstration of the design technique is required.

Expected Project:

Final Proj: Control of Electric Drive

Lab Experience and Report:
The labs shall be designed to give basic understanding of parameter measurement of converter under study. In addition, the lab shall utilize software tools in aid of analysis. Lab report shall follow a prescribed format, and be graded on completeness, correctness, presentation and analysis of data.

Expected Lab Experiments:

Exp1: Controlled rectifier
Exp2: dc-dc converter applications

Text Books:

1) Fong Mak, Class notes for ECE465/GECE565;
2) Muhammad H. Rashid, *Power Electronics Circuit, Devices, and Applications*, 3rd Edition, Prentice Hall, 2004.
3) Marc E. Herniter, *Schematic Capture with Cadence PSpice*, Prentice Hall, 2001.

Reference Texts:

1) Mohan, Underland, Robbins, *Power Electronics Converters, Applications, and Design*, 2nd Edition, Wiley, 1995.

Course Policies:

- Integrity: Cheating in any form will not be tolerated. Willfully misrepresenting your work in this class may result in an "F" grade for the course. Please refer to the *Gannon University Code of Academic Integrity*.
- Testing: The test procedure will be announced prior to the examinations. Anyone violating the testing procedure will be dropped from class.
- Attendance: Three inadequately excused absences from class will result in a grade of **F.**
- Submission: Homework assignments are due before the class time of the due date. No late homework assignments will be accepted.
- Individual Assignments: Students are encouraged to discuss course topics and homework assignments with each other. However duplicate assignments are not allowed. All submissions must represent your own work.
- Resubmission of Key Assignments: Students may elect to resubmit *key assignments* that have already been graded. To resubmit a key assignment, the original graded assignment and the resubmission must be submitted together. The student must schedule an oral review of the assignment with the instructor. Resubmissions may only receive 90% of the maximum grade allowable on the first submission. Assignments may only be resubmitted once. All assignments must be resubmitted prior to the final examination.

Grading Policy:

Step 5 info entered here

Passing Objective Criteria:

To receive a passing grade in this course, all students must meet the following minimum criteria demonstrating how well they have mastered the course learning objectives. Each objective is assigned one or more Key Assignments, which will be graded specifically on the course objective(s) and related program objective(s) listed below. Students will not be eligible to receive a passing grade for the course unless all Key Assignments are successfully completed, demonstrating minimal mastery of the course objectives.

- **Understand the fundamental principles on various power converter topologies, design of power converter, and the related performance analysis**
  Demonstrate a foundation in applied math, ability to formulate eng problem, solve eng problems:
  Key Assignment: Proj5 passed with a grade of C or better.
  Description: Proj 5 requires student to design a converter against criteria given and simulate to verify the design. Hence it is used as a gauge to "applied math", "formulate eng problem" and "solve eng problem"
  A&D of complex electrical & electronics systems:
  Key Assignment: Part A of Final Project passed with a grade of C or better for this section.
  Description: Part A requires A&D of an inverter design. Part B includes the design of filter and integration of a front-end converter. Successful completion of part A indicates the acquired skill.

- **Develop skills in using contemporary software tools for modeling and its analysis**
  Demonstrate ability to use technique, skills, and modern tools:
  Key Assignment: Part A of Final Project passed with a grade of C or better.
  Description: Part A of final requires student to apply software skills learned in the course independently in analysis and design of the problem. Correct completion of part A indicates the needed skills have been acquired.

- **Develop skills in the construction and parameter measurement of converters**.
  Demonstrate a professional ability to conduct experiments, analyze & interpret experimental data:
  Key Assignments: Exp 1 short report and Exp2 short-report (combined average of a grade of C or better)
  Description: Short reports are accepted only after the corresponding experiment has been conducted. Data are required to be analyzed accordingly.

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With successful completion of the minimum passing criteria on all key assignments, the following is the overall grading for the class.

Homework and projects	50%
Mid-term Exam or project	20%
Final Exam or project	30%

Step 6 info entered here

Relationship to Program Outcomes and Objective Evidence:

Program Outcomes Met	Course Objective	Objective Evidence
Foundation in applied math	1	Proj 5
A&D of complex electrical & electronics systems	1	Final Proj
Formulate engineering problem	1	Proj 5
Solve engineering problem	1	Proj 5
Ability to use technique, skills, and modern tools	2	Final Proj
Conduct Experiment	3	Exp 1 and 2
Analyze & interpret experimental data	3	Exp1 and 2

--end of ECE465 Syllabus --

Figure 3 ECE 465 course syllabus

Figure 3 illustrates the syllabus format that the department adopted. The following key phrase is critical to note:

> *"To receive a passing grade in this course, all students must meet the following minimum criteria demonstrating how well they have mastered the course learning objectives. Each objective is assigned one or more Key Assignments, which will be graded specifically on the course objective(s) and related program objective(s) listed below. Students will not be eligible to receive a passing grade for the course unless all Key Assignments are successfully completed, demonstrating minimal mastery of the course objectives*"

This has been adopted as a standard phrase for the grading policy on each ECE course syllabus. This policy is announced at the beginning of the semester when the faculty reviews the syllabus with the students.

Figure 3 also illustrates another aspect of the key assignment concept: a resubmission policy. The course policy adopted by the department for all courses states: "*Students may elect to resubmit key assignments that have already been graded…"* The issue here is to ensure that students have the opportunity to learn – especially from their mistakes. Each key assignment essentially becomes a pass/fail criterion for the course, so the students must meet the minimum grading criteria for the assignment or fail the course. These concerns were clearly seen with the pilot courses. To ameliorate these effects, the department agreed that students should have the ability to resubmit key assignments, so they have the opportunity to demonstrate their mastery of the key (required) material.

Another aspect of the key-assignment policy is that it gives the faculty the opportunity to explain to the students what the program learning outcomes are, and how this course that they are taking helps them meet these outcomes. This focus on course and program outcomes was one of the lessons learned from the pilot courses.

Lesson learned:

Student's perspective: At first, there were quite a bit of anxiety and concern among students knowing that they cannot pass the course even though they have done well for the rest of the assignments or examinations if they do not pass the key assignments. Mostly the concern is due to the "what if" they cannot complete the key assignments for whatever reason, it will not be fair for them to go through the entire semester's learning for nothing. To alleviate this concern, the following actions are taken:

- The re-submission of key assignments policy is instituted (see syllabus).
- Reminder to key assignments is made when the assignments are given.

We found that students tend to pay more attention to key assignments and submit better prepared assignments accordingly. In the process of doing so, students are better aware of the course objectives and how they are measured. Students gave more comments to the class in their course-exit surveys. Following are some comments from students:

- "*Make every class similar in teaching method. Learn stuff, do a project, then model a lab experiment off of the projects*."
- "*No material should be omitted from this course. Everything that was learned was useful.*"
- "*One future improvement would be to take out one project and replace it with additional problems from the textbook. I believe that these problems would give more detailed explanation to some of the converters under study*."

Faculty's perspective: In the past, it is customary to collect objective evidence from a sample of poor, averaged, and good students' assignments. However, there is always a lack of justification of how those assignments collected satisfying the claim on meeting course objectives. There is always a warm and fuzzy feeling that the justification is embedded in the assignments if you look closely enough. With this proposed process, the justification on objective evidence is documented and easily assessable by others who are not necessary the instructor. This process has certainly simplified the burden on the Chair in examining the objective evidence submitted.

Conclusions:

The department believes by implementing the key assignment policy and associated process, the measurement of course objectives will be accountable and backed by the justifiable objective evidence. Students will have a keen awareness of where they are being asked to demonstrate their abilities with respect to the course outcomes, and be aware of their progress. By passing the course, students will satisfy the course objectives, which in turn will meet the corresponding program outcomes. Therefore, as long as the overall curriculum matrix covers all program outcomes upon students' graduation, each and every student will meet all the program outcomes accordingly.

To date, only two courses have been implemented with this change. With the apparent success of the pilot courses, this process will be carried out on all departmental courses over to the Spring 2004 semester. Assuming the continued success of the experiment, the process will continue until all courses in the curriculum matrix adhere to this minimum grading policy procedure.

Bibliography:

[1] Engineering Criteria 2000 3rd Edition: Criteria for Accrediting Programs in Engineering in the United States. Published by The Accreditation Board for Engineering and Technology (ABET), Baltimore MD. 1997. Available: http://www.abet.org/EAC/eac2000.html.

[2] Felder, R.M., Brent, R., "Designing and redesigning courses to address EC2000," *Frontiers in Education 2001*, Reno, Nevada, October 2001.

[3] Mak, F., Frezza, S., Yoo, W.S., "Web-based course-exit survey for ABET EC2000," *ASEE Annual Conference and Exposition*, Nashville, TN, June 2003.

[4] Mak, F, Yoo, W.S., Frezza, S., "Enhancing ABET EC2000 preparation using a web-based survey/reporting tool," *ASEE/IEEE 33rd Frontiers in Education Conference*, Boulder, Co, November 2003.

Biographies:

FONG MAK, P.E. received his B.S.E.E. degree from West Virginia University in 1983, M.S.E.E. and Ph.D. in Electrical Engineering from the University of Illinois in 1986 and 1990. He is currently the Chair of Electrical and Computer Engineering at Gannon University. He is also the Program Director for the professional-track Gannon/General Electric Transportation Systems (GETS) Embedded Software Graduate Program.

STEPHEN FREZZA, C.S.D.P. received his B.S., M.S., and Ph.D. degrees in Electrical Engineering from the University of Pittsburgh in 1985, 1991 and 1995. He is an associate professor of Electrical and Computer Engineering at Gannon University. His research interests include engineering education, systems and software engineering.