Curriculum Assessment and Enhancement at Purdue University Calumet Based on ABET 2000

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Abstract ? For the first time, in fall 2003, the engineering department will have an accreditation based on ABET (Accreditation Board for Engineering and technology) Engineering Criteria 2000. ABET 2000 requires: "a system of ongoing evaluation that demonstrates achievement of program objectives and uses the results to improve the effectiveness of the program," and "each program must have an assessment process with documented results." Evidence must be given that the results are applied to the further development and improvement of the program. In this paper, the assessment plan for the engineering department is outlined.

INTRODUCTION

The Purdue Calumet engineering curriculum leads to a Bachelor of Science in engineering degree and is particularly aimed at students who work in industry. The students specialize in Electrical Engineering, Computer Engineering, or Mechanical Engineering. First generation students count for 74% of student body with 25% minorities based on numbers obtained from the fall 2000 admitted students. Half of the students are part-time. Based on the current university strategic planning, the goal is to improve new freshman retention rates from 62% to 72% and improve the six year graduation rate from 22% to 32%, with aspirations of 40%.

The electrical and mechanical engineering programs are due for reaccreditations. The new computer engineering program will be up for accreditation for the first time in fall 2003. As mentioned, the goal of ABET is to promote continuous quality improvement in engineering education through faculty guidance and initiative. The new system for accreditation, ABET 2000, differs from predecessor in Criteria 2 and 3 [1]. Work presented in this paper also concentrates on Criteria 2 (program objectives) and 3 (program outcomes and continuous program improvement).

During the past few years, the engineering department worked on developing an assessment and enhancement process for the Bachelor of Science programs based on ABET 2000 criteria. Figure 1 shows the developed assessment process for continuous improvement. The objective of the process is to provide a systematic pursuit of excellence and satisfaction of the needs of constituencies. Throughout the paper different components of the process shown in figure 1, will be explained.

Program Educational objectives

ABET criteria 2 requires each engineering program for which an institution seeks accreditation must have a detailed educational objectives that are consistent with the mission of the institution and supported by the curriculum. Well-stated program educational objectives identifies the needs of constituencies based on document able, quantifiable input and will indicate specific program focus [1,4]. Each engineering program must have a system of ongoing evaluation that demonstrates achievement of these objectives and uses the results to improve the effectiveness of the program.

Educational objectives shown in table 1 are developed by the faculty with the feedback from engineering department industrial advisory committee. As shown in figure 1, the program objective should be consistent with the department mission. The objectives describe the expected accomplishments of the graduates during the first few years after graduation.

Program Outcomes and Assessment

After stating the program objectives as required in criterion 2, the program outcomes need to be stated. A well stated program outcome should encompass ABET "a-k", should be supported by curriculum, and should be linked to program educational objectives. The outcomes describe what students are expected to know and able to do by the time of graduation.

Table 1 also shows the twelve outcomes for our program and its link to the educational objectives. The first 11 outcomes "a-k" are the one dictated by ABET. We have added one extra outcome in addition to the required ones which is specific to our program.

Assessment process must demonstrate the outcomes and the objectives of the program are being measured. Usually program outcomes provide general information about the program and thus are not measurable. In order to measure

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outcomes performance criteria are developed for each outcome. Performance criteria indicate what concrete actions the students should be able to perform in order to demonstrate the outcome.

Performance criteria for each outcome are shown in table 2. The performance criteria facilitate the curriculum delivery strategies, and assessment procedures [2,3]. The performance criteria should be achievable with the provided resources of the program. Next, a strategy and an assessment method for each performance criteria need to be stated. Strategy will indicate what specifically is done to provide the students with the opportunity to achieve the performance criteria. Assessment is a process that identifies, collects, and prepares data that can be used to evaluate achievement. All the above information are documented in outcome notebook (table 6).

It is suggested to use more than one assessment method for each performance criteria with the mixture of direct and indirect methods. Example of direct method is like written test items clearly linked to course learning objectives or observing a student communication skill during project oral presentation. Indirect assessment method may include use of surveys. There are number of assessment methods and list of different assessment techniques can be found in [5].

Table 3 indicates the primary courses supporting the outcomes. Initially, all the courses in the curriculum contributing to outcomes were included. To streamline the process, it was decided to include one, two, or maximum three courses and these are courses that will extensively be assessed and included in the outcome notebook (table 6). Of course it is still important to indicate all the courses throughout the curriculum that contribute to a specific outcome. Table 4 shows the program outcome flowchart for outcome b for the computer program. The various numbers inside the parentheses indicate the level of contribution that the course provides to the outcome. Program outcome flowchart indicates where in the curriculum the students are given the opportunity to learn, apply, and demonstrate the outcome.

In order to document the assessment and enhancement process, course journal and outcome notebooks are kept. The contents of course journal and outcome notebooks are shown in table 5 and 6, respectively. The purpose of course journal is to document course learning objectives and its assessment. ABET 2000 criterion 3 focuses on outcome based assessment and not courses. ABET evaluators will concentrate on insuring that the listed program outcomes are achieved and there is an enhancement process in place. Outcome notebook will provide the needed documentation for each outcome.

The course contribution to each outcome through its learning objectives is indicated in table 7. The program assessment matrix indicates the course level of contribution to program outcomes. The program outcome flowchart is constructed based on information received for each course in table 7.

From beginning our goal was to design an assessment and enhancement process which is effective, simple, and implementable. Steps taken include limiting the number of performance criteria for each outcome, selecting primary courses addressing each outcome, making each faculty responsible for an outcome.

In summary the following steps are taken to prepare for ABET visit addressing ABET criterion 2 and 3:

- Developed an outcome-based engineering program assessment & enhancement process (figure 1)
- Identified relationship between program educational objectives and outcomes (table1)
- Developed performance criteria for engineering program outcomes (table 2)
- Specified one or two supporting courses for assessing each outcome (table 3)
- Developed and implemented program outcome flowchart (table 4)
- Published educational objectives and program outcomes on the WEB
- Developed and conducted undergraduate surveys
- Developed and conducted senior exit interviews
- Updated list of course responsibility for each faculty
- Developed a standard for syllabi with learning objectives for engineering courses
- Developed and conducted course assessment reports
- Specified process time schedule
- Revised and streamlined the assessment procedure based on feedback received

Currently, based on process time schedule the department is involved with enhancement phase. This phase usually refereed to as closing the process loop as shown in figure 1.

REFERENCES

[1] ABET Criteria for accrediting engineering programs: Effective for evaluations during the 2002-2003 accreditation cycle .http://www.abet.org/images/Criteria/2002-03EACCriteria.pdf, accessed February 2, 2003.

[2] http://civeng1.civpitt.edu/~ec2000, accessed February 2, 2003.

[3] Besterfield-Sacre, M.E., et al., "Defining the Outcomes: A Framework for EC 2000", *IEEE Transactions on Engineering Education*, 43(2), 2000, pp.100-110.

[4] Carter,M.,R.Brent, and S. Rajala,"EC 2000 Criterion 2: A procedure for creating, assessing, and documenting program educational objectives", *Proceedings of 2001 ASEE Annual Conference*, American Society for Engineering Education, 2001.

[5] Felder, R., and R. Brent," Designing and Teaching Courses to Satisfy the ABET Engineering Criteria", *Journal of Engineering Education*, Vol.92, No. 1, January 2003, pp. 7-18.

Figure 1 BS Engineering Program Assessment & Enhancement Process

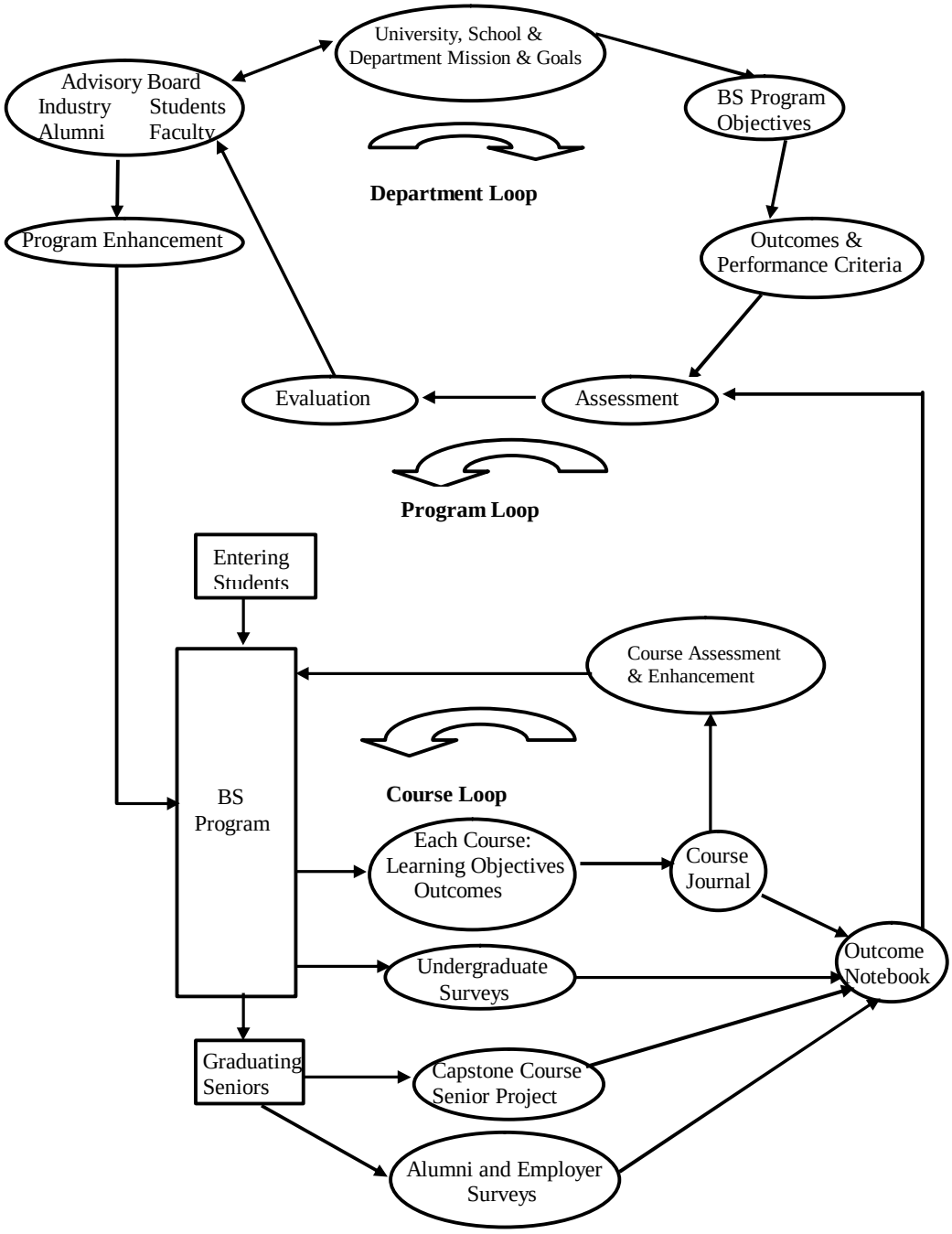

Table 1 Relationship between Educational Objectives and Outcomes Computer Option Program

The Computer Option curriculum provides a broad education in the fundamentals of Computer Engineering. Students may pursue a general program or may choose a specialization in areas such as Computer Hardware or Computer Software.

Program Educational Objectives	**Program Outcomes**
1. **Engineering Competence**- Graduates will be competent engineers with problem solving and design skills, and the capability to apply mathematics and science to solve engineering problems.	Outcome a: Have an ability to apply knowledge of **mathematics, science and engineering**. Outcome b: Have an ability to design and conduct **experiments**, as well as to analyze and interpret data. Outcome c: Have an ability to **design** a system, component or process to meet desired needs. Outcome e: Have an ability to identify, formulate and solve engineering **problems**.
2. F**oundation in modern technologies** - Graduates will have extensive knowledge about current technologies.	Outcome k: Have an ability to use the techniques, skills, and **modern engineering** tools necessary for engineering practice.
3. **Professional skills** - Graduates will have strong communication skills, and the ability to work successfully in teams. They will be well prepared for work in industry.	Outcome d: Have an ability to function on **multi-disciplinary teams.** Outcome g: Have an ability to **communicate** effectively. Outcome l: Have an ability to apply their engineering knowledge to solve **industrial** problems, and enhance industrial profitability
4. **Creativity and drive for technical innovation** - Graduates will be self-motivated, creative people who promote technical innovation and have enthusiasm for life-long learning.	Outcome i: Have recognition of the need for, and an ability to engage in **life-long learning**.
5. **Well-rounded education –** Graduates will have knowledge of contemporary issues, an understanding of professional and ethical responsibility, and possess a general education necessary to understand the impact of engineering solutions in a global and societal context.	Outcome f: Have an understanding of **professional** and **ethical responsibility**. Outcome h: Have the broad education necessary to understand the impact of engineering solutions in a **global/societal** context. Outcome j: Have knowledge of **contemporary issues.**

Table 2: Engineering Program Outcomes and Performance Criteria

Outcome a: Graduates will have the ability to apply knowledge of mathematics, science, and engineering. Specifically, students will be able to

1. Use concepts from science to solve engineering problems.
2. Formulate analytical models using the laws of physics.
3. Use appropriate mathematical tools to solve equations.

Outcome b: Graduates will have the ability to design/conduct experiments and analyze/interpret data. Specifically, students will be able to

1. Design an experiment, including determining the data to be collected, the range of parameter values, and the use of statistical analysis.
2. Conduct an experiment and compare experimental with predicted or expected results.
3. Prepare reports that present the data from an experiment, interpret the data/results, and draw conclusions and make recommendations.

Outcome c: Graduates will have the ability to design a system, component, or process to meet desired needs. Specifically, students will be able to

1. Determine the necessary constraints and specifications.
2. Design components that meet specifications and constraints
3. Design a system or process that meets specifications and constraints.

Outcome d: Graduates will have the ability to function on multidisciplinary teams. Specifically, students will be able to

1. Function as a team leader and/or team member in laboratory and problem-solving activities.
2. Function as a team leader and/or member in a senior design project.
3. Effectively participate in team-based oral and written reporting activities.

Outcome e: Graduates will have the ability to identify applicable theories, and formulate and solve engineering problems. Specifically, students will be able to

1. Demonstrate an ability to formulate engineering problems, to recognize the relevant signals/ parameters, and to identify the governing theories and principles.
2. Create sketches, figures, flow-charts, and free-body diagrams.
3. Show understanding of the applicable theories and principles by demonstrating the use of relevant formulae and relationships.

Outcome f: Graduates will understand professional and ethical responsibility. Specifically, students will be able to

1. Demonstrate knowledge of safety factors in the design process.
2. Demonstrate knowledge of professional code of ethics.
3. Evaluate the ethical issues of an engineering problem.

Outcome g: Graduates will have the ability to communicate effectively. Specifically, students will be able to

1. Develop and present effective oral presentations that integrate appropriate visuals.
2. Write documents that are well organized, properly formatted, and clear.
3. Convey technical information through the use of data plots, graphs, calculations, drawings, and equations.
4. Communicate effectively with team members.

Outcome h: Graduates will have the broad education necessary to understand the impact of engineering solutions in a global/social context. Specifically students will be able to

1. Demonstrate knowledge of the impact of the products on society and the environment, including both production, and use.
2. Demonstrate an understanding of the impact of engineering decisions on society and the environment.

Outcome i: Graduates will recognize of the need, to engage in life-long learning. Specifically, students will be able to

1. Investigate and gather information on a given engineering issue.
2. Recognize the need for continuing education, and participation in professional societies and meetings.

Outcome j: Graduates will have knowledge of contemporary issues. Specifically, students will be able to

1. Identify several contemporary issues.
2. Investigate, gather, and analyze information related to contemporary issues.
3. Describe the impact of social, environmental, legal, and other contemporary issues on engineering activities.

Outcome k: Graduates will have an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice. Specifically, students will be able to

1. Use libraries, the internet, and other sources to search for information necessary for engineering projects.
2. Use computer programs in analysis, simulation, and design of systems and components.
3. Use modern instrumentation to conduct experiments on components and systems.

Outcome l: Graduate will have the ability to apply their engineering knowledge and experience to solve industrial problems, and to enhance industrial profitability. Specifically, students will be able to

1. Work in cross-discipline teams.
2. Plan and execute projects, and prepare the necessary oral and written reports.
3. Identify engineering solutions within time and budget constraints.

Table 3 Primary Courses Supporting Outcomes

Outcome	BSCE	BSEE	BSME
a. Math & Science Engr. (Kozel)	**ECE** 301, 311	**ECE** 301, 311	**ME** 271, 312
b. Experiments/Data (Pai/Gopalan)	**ECE** 370, 464	**ECE** 218, 275, 335	**ME** 345, 417
c. Design (Burridge)	**ECE** 370 **ENGR** 440, 460	**ECE** 370 **ENGR** 440, 460	**ME** 466 **ENGR** 440, 460
d. Multidisciplinary Teams(Pierson)	**ENGR** 190, 440, 460	**ENGR** 190, 440, 460	**ENGR** 190, 440, 460
e. Engr. Problem Solving (Mojtahed)	**ECE** 201, 301	**ECE** 201, 301	**ME** 275, 320, 461
f. Professional & Ethics (Gerber)	**ENGR** 440 **PHIL** 324	**ENGR** 440 **PHIL** 324	**ENGR** 440 **PHIL** 324
g. Effective Communication (Abramowitz)	**ENGR** 460	**ENGR** 460	**ENGR** 460 **MSE** 344
h. Global & Societal (Hentea)	**ENGR** 440, 460	**ENGR** 440,460	**ENGR** 440, 460
i. Life-Long Learning (Zhou)	**ENGR** 195A, 440, 460	**ENGR** 195A, 440, 460	**ENGR** 195A, 440, 460
j. Contemporary Issues (Kin)	**ENGR** 190, 440, 460	**ENGR** 190, 440, 460	**ME** 461 **ENGR** 440, 460
k. Modern Tools (Gray)	**ECE**, 160, 370, 380	**ECE** 160, 370, 380	**ME** 461, 486 **ENGR** 380
l.. Solving Industrial Problems (Pierson/Nnanna)	**ENGR** 440, 460	**ENGR** 440, 460	**ENGR** 440, 460

Table 4 Example of Program Outcome Flowchart

Outcome b: Graduates Must Have an Ability to Design and Conduct Experiments/Analyze and Interpret Data

Semester	Courses (Level of Contribution) (Level 1 = Objective Addresses Outcome Slightly, 2 = Moderately, 3 = Substantially)
Freshman Fall	CHM 115 (**2**), ENGR 190 (**2**)
Freshman Spring	PHYS 152 (**2**)
Sophomore Fall	ENGR 233 (**1**), ECE 207(**3**)
Sophomore Spring	ECE 370 (**3**), ECE 218(**3**)
Junior Fall	ECE 330 (**1**), ECE 275 (**3**)
Junior Spring	ECE 371 (**2**), ECE 459 (**3**)
Senior Fall	ECE 464(**3**), ECE 476(**2**), ENGR 380 (**2**)
Senior Spring	

Table 5 Example Course Journal Table of Contents

Tab 1: Goals & Objectives
- Course Goals
- Student Learning Objectives
- Outcome Contribution

Tab 2: Homework & Exams
- List/Description of Homework Assignments
- Exams with Grading Statistics
- Quizzes

Tab 3: Labs & Projects
- Description & Assignment:
  - Computer Laboratory Assignments
  - Physical Laboratory Experiments

Tab 4: Significant Handouts

Tab 5: Course Assessment
- Report
- Student Statistics
- Surveys
- Grade Distribution

Table 6 Example Outcome Notebook Table of Contents

Table 7 Program Assessment Matrix

Course Number: Course Name:
Evaluator: Date of Evaluation:
(See notes at end of table to explain abbreviatio

Topic Number	Major Program Outcomes Topic	Assessable Component(s)	Level of Contribution (1, 2 or 3)	Assessment Method(s) (EXAM, HW. EXP. IP, TP, NA, Other)	Prerequisites	
					Course(s)	Topic
Outcome	Description		Level			
a	Ability to apply knowledge of mathematics, science and engineering					
b	Ability to design/conduct experiments and analyze/interpret data					
c	Ability to design system, component or process to meet desired needs					
d	Ability to function on multi-disciplinary teams					
e	Ability to identify, formulate and solve engineering problems					
f	Understanding of professional an ethical responsibility					
g	Ability to communicate effectively					
h	Understand the impact of engineering solutions in a global/societal context					
i	Recognition of the need for and an ability to engage in life-long learning					
j	Knowledge of contemporary issues					
k	Ability to use the techniques, skills and modern tools necessary for engineering practice					
l	Ability to Apply Engineering Knowledge to Solve Industrial Problems and enhance Industrial Profitability					

Notes for Table 8:	
Assessable Component(s)	NP - Not a Priority in this Class Otherwise, please list specific activities related to this attribute.
Level of Contribution	1 = Slightly, 2 = Moderately, 3 = substantially
Assessment Method(s) Used to Evaluate Level of Student Capability In Priority Order	EXP = Experiment TT = Team Test HW - Graded Homework Problems TPS = Team Problem Solving IP - Individual Project/Report TP = Team Project TR = Team Report NA - Not Assessed Other = Any other method that is applied