CASE STUDY: DEVELOPMENT & IMPLEMENTATION OF EC 2000 WITHIN THE MECHANICAL ENGINEERING PROGRAM AT GEORGIA TECH

William J. Wepfer
Eugene C. Gwaltney School Chair & Professor
The Georgia W. Woodruff School of Mechanical Engineering
Georgia Institute of Technology
Atlanta, GA 30345 USA

November 8, 2012

ABET
Assuring Quality • Stimulating Innovation

Background: Mechanical Engineering at Georgia Tech

- Large state-supported institution with a mission that includes both high-level research as well as educating large numbers of students at the bachelor's, master's, and doctoral levels.
- Historical has graduates between 2-3% of all bachelor's degrees in mechanical engineering in the USA (>400 BSME/year)

Administration & Faculty Governance

- School Chair reports to the Dean of Engineering
- Associate Chair for Undergraduate Programs
- Associate Chair for Graduate Programs
- Undergraduate Curriculum Committee
- Graduate Committee
- External Advisory Committee (started in 1984)
- Institute-level committees for university approval of school/departmental actions
- State Board of Regents for approval of campus-level actions

ABET Evaluations Before EC 2000

- 1984 Visit: We were cited for poor laboratories, which resulted in significant new resources and a stellar 1987 interim visit.
  - To this day, our instructional laboratories remain a strength due to the ABET evaluation process.

Pre-EC 2000 Criteria

IV.C.1 Faculty

IV.C.2 Curricular Objective

IV.C.3 Curricular Content

IV.C.4 Student Body

IV.C.5 Administration

IV.C.6 Institutional Facilities

IV.C.7 Institutional Commitment

Highly detailed and proscriptive language (many paragraphs) detailing specific requirements!

Pre-EC 2000 Mechanical Engineering Program Criteria

- Faculty
  - **Faculty Qualifications & Size.** Mechanical engineering programs must have at least five full-time faculty members who by training and/or practice are competent in mechanical engineering and whose primary responsibility is the instruction of undergraduate mechanical engineering students.
  - **Faculty Workload.** A full-time faculty workload must reflect all appropriate activities, e. g., teaching, research, advising, institutional and committee service, and professional society responsibilities. The evaluation of the teaching load should reflect class size, modality of instruction, instructional support, and contact hours.
  - **Faculty Participation.** Faculty members shall be involved with the professional development of students, providing students with the opportunity to interact with practitioners in their major fields through a student organization, or equivalent experience, that has the demonstrated support of the academic unit administering the program.

Pre-EC 2000 Mechanical Engineering Program Criteria

- Curriculum
  - **Curricular Objective & Content.** The basic-level curriculum shall include two stems of coherent course offerings: (1) energy, and (2) structures and motion in mechanical systems.
  - **Engineering Sciences.** A coherent program shall include at least one course in the electrical sciences.
  - **Engineering Design.** It is required that some integrated educational experience in the terminal portion of the program be dedicated primarily or in its entirety to engineering design. Documented evidence of the student's participation must be provided for the visitor's evaluation.
  - **Computer Use.** Graduates must have substantial experience in computer applications in both the energy and mechanical systems stems.

General Comments on Strengths of Pre-EC 2000 Approach

- Detailed emphasis on inputs to the educational process.
- Detailed emphasis on curricular content.
- Allowed a highly granular approach to what elements the curriculum should contain.
- Very specific delineation on what faculty members should do.

General Comments on Weaknesses of Pre-EC 2000 Approach

- Focused only on inputs: did not pay attention to outputs or evaluations thereof.
- Highly internally-focused. Little or NO engagement of external constituencies.
- Allowed our Associate Chair and Curriculum Committee to be the sole owners of ABET — did not encourage a wider faculty buy-in or participation of strategic curricular objectives.

EC 2000: What Was New?

- Focus on outcomes
- Focus on the role programs play within the broader mission of the institution
- Focus on continuous improvement: process focus
- Recognized importance of external constituencies and sough their input
- Required broader engagement of faculty members

Contextual Definitions (current)

- **Program Educational Objectives.** Program educational objectives are broad statements that describe what graduates are expected to attain within a few years of graduation. Program educational objectives are based on the needs of the program's constituencies.
- **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.

Contextual Definitions (current)

- **Assessment.** Assessment is one or more processes that identify, collect, and prepare data to evaluate the attainment of student outcomes and program educational objectives. Effective assessment uses relevant direct, indirect, quantitative, and qualitative measures as appropriate to the objective or outcome being measured. Appropriate sampling methods may be used as part of an assessment process.
- **Evaluation.** Evaluation is one or more processes for interpreting the data and evidence accumulated through assessment processes. Evaluation determines the extent to which student outcomes and program educational objectives are being attained. Evaluation results in decisions and actions regarding program improvement.

EC 2000 Criterion 1: Students

- Quality and performance of students and graduates became an important success factor.
- The institution was now required to advise, evaluate, and monitor student performance and progress toward their degrees.
- ***This did not pose any difficulties. The Georgia Tech ME Program as well as the Registrar's Office had well-developed and documented processes in place.***

EC 2000: Criteria 2 & 3

THIS WAS THE HARD PART!

EC 2000: Criterion 2: Program Educational Objectives

- Detailed Program Educational Objectives (PEOs) that address (and are linked) to the program/student outcomes specified by the criteria.
- A process, based upon the needs of constituents, in which objectives are determined and evaluated.
- A curriculum and process that ensures the achievement of these objectives.
- A system of on-going evaluation that demonstrates achievement of these objectives and uses the results to improve the effectiveness of the program.

EC 2000: Criterion 3: Outcomes & Assessment

- Demonstrate that students have achieved the desired outcomes by the time of graduation.
- Measure outcomes important to mission and objectives.
- Apply results to further develop and continuously improve the program.
- Assure that all students meet all program graduation requirements.

Criterion 3: Current Student Outcomes

(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

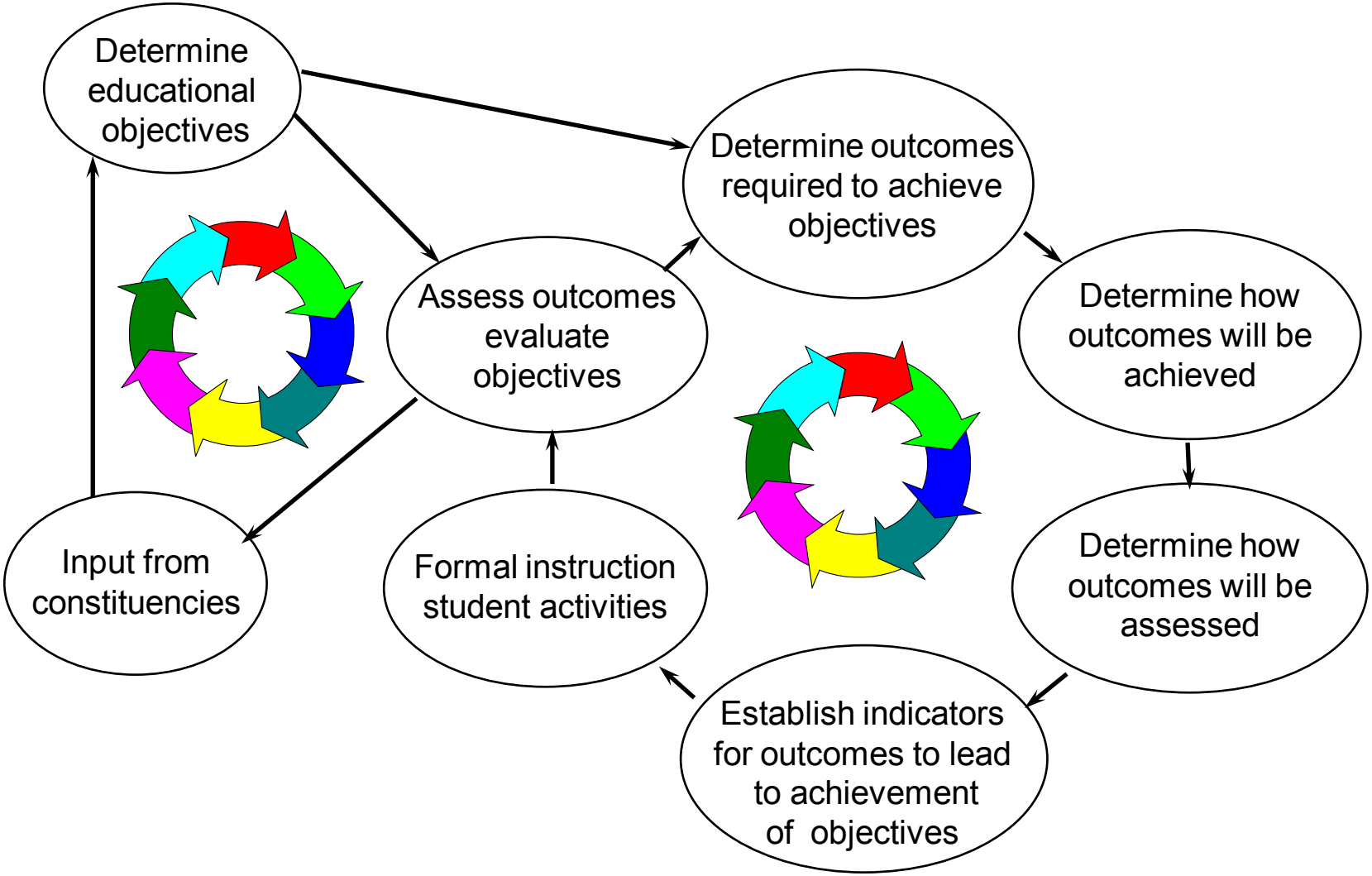
(h) the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context

(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.

Systematic Approach



Criterion 2 & 3 Challenges

- Linkage of PEOs with the institutional mission
- Attempted to provide flexibility to programs to develop unique attributes
- Engagement of external constituencies
- Measurement and evaluation of the accomplishments of graduates a few years out
- Learning how to sync the longer-range assessment and evaluation of PEOs with the shorter-range student outcomes
- How to map and relate PEOs with student outcomes

More Criterion 2 & 3 Challenges

- How does one measure the attainment of the student outcomes (a)-(k)?
  - Course by course?
  - Which courses?
  - How frequently?
  - Faculty buy-in?
  - How to relate these results with attainment of PEOs?
  - Sampling?
  - Faculty evaluation of attainment of outcomes?
- How to develop efficient measurement tools
- Establishing metrics for student attainment

Criterion 4: Professional Component

- Faculty members must assure that the curriculum devotes adequate attention and time to each component, consistent with the program's PEOs and institutional mission.
- One year of a combination of college level mathematics and basic sciences appropriate to the discipline.
- One and a half years of engineering topics to include engineering sciences and engineering design appropriate to the student's field of study.
- A general education component that complements the technical content of the curriculum and is consistent with the programs and institution objectives.
- Preparation for engineering practice to include a major design experience.

Criterion 4: Major Design Experience

- A culminating experience, based on knowledge and skills acquired in earlier coursework
- Must incorporate engineering standards and realistic constraints, including most of the following: economic, ethical, environmental, health and safety, sustainability, social, manufacturability, and political

- ***This change, other than the issue of standards and realistic constraints, did not cause us problems!***

Criterion 5: Faculty

- Sufficient Number
  - Adequate levels of student-faculty interaction
  - Student advising and counseling
  - University service activities
  - Industry interaction
  - Professional development
- Competent to cover all curricular areas of program
- Ensure proper guidance of the program, its evaluation and guidance
- ***This change did not cause any difficulties. It does put a significant interpretation burden on the program evaluator.***

Criterion 6: Facilities

- Must provide opportunities for students to learn use of modern engineering tools
- Classrooms, laboratories, and equipment must be adequate to:
  - Accomplish program objectives
  - Foster faculty-student interactions
  - Encourage professional development
- Computing and information infrastructure must be adequate to support:
  - Scholarly activities of students and faculty members
  - Educational objectives
- ***This change did not cause any significant difficulties.***

Criterion 7: Institutional Support and Financial Resources

- Constructive leadership
- Financial resources
  - Sufficient to acquire, maintain, and operate facilities
  - Sufficient to attract, retain, and provide for continued professional development of faculty
- Technical and clerical services
- ***This change did not cause any significant difficulties.***

Mechanical Engineering Program Criteria

- Old: Curriculum
  - **Curricular Objective & Content.** The basic-level curriculum shall include two stems of coherent course offerings: (1) energy, and (2) structures and motion in mechanical systems.
  - **Engineering Sciences.** A coherent program shall include at least one course in the electrical sciences.
  - **Engineering Design.** It is required that some integrated educational experience in the terminal portion of the program be dedicated primarily or in its entirety to engineering design. Documented evidence of the student's participation must be provided for the visitor's evaluation.
  - **Computer Use.** Graduates must have substantial experience in computer applications in both the energy and mechanical systems stems.

Mechanical Engineering Program Criteria (cont.)

- New: Curriculum
  - The curriculum must require students to apply principles of engineering, basic science, and mathematics (including multivariate calculus and differential equations); to model, analyze, design, and realize physical systems, components or processes; and prepare students to work professionally in both thermal and mechanical systems areas.
- ***A significant change that did not cause problems.***

Mechanical Engineering Program Criterion

- Old: Faculty
  - **Faculty Qualifications & Size.** Mechanical engineering programs must have at least five full-time faculty members who by training and/or practice are competent in mechanical engineering and whose primary responsibility is the instruction of undergraduate mechanical engineering students.
  - **Faculty Workload.** A full-time faculty workload must reflect all appropriate activities, e.g., teaching, research, advising, institutional and committee service, and professional society responsibilities. The evaluation of the teaching load should reflect class size, modality of instruction, instructional support, and contact hours.
  - **Faculty Participation.** Faculty members shall be involved with the professional development of students, providing students with the opportunity to interact with practitioners in their major fields through a student organization, or equivalent experience, that has the demonstrated support of the academic unit administering the program.
- New: Faculty
  - The program must demonstrate that faculty members responsible for the upper-level professional program are maintaining currency in their specialty area.
- ***A significant change that did not cause problems.***

ASME Committee on Engineering Accreditation 2001 Study of EC 2000

Schools Surveyed

- Alfred University
- University of Arkansas
- Clemson University
- University of Colorado
- University of Denver
- Georgia Tech
- Johns Hopkins University
- University of Houston
- Idaho State University
- University of Kentucky
- University of Michigan

Early EC 2000 Evaluations

- Mississippi State University
- University of North Dakota
- Northwestern University
- Ohio State University
- University of Pittsburgh
- San Jose State University
- University of South Alabama
- University of South Carolina
- University of Tennessee
- Worcester Polytechnic Institute

ASME Committee on Engineering Accreditation 2001 Study of EC 2000 – What Went Well

- Forced entire program faculty to be engaged in the establishment of PEOs, student outcomes, and the assessment processes.
- Continuous improvement provided non-threatening feedback to individual faculty members.
- Catalytically sparked the creation and involvement of external advisory boards, especially contributing to the improvement of the culminating design experience.
- Graduating senior exit surveys, evaluations of capstone design projects by industry representatives, and faculty-student focus groups identified as assessment mechanisms that provided valid data and led to program improvements.

ASME Committee on Engineering Accreditation 2001 Study of EC 2000 – What Did Not Go So Well

- Employer survey response rates were much lower than expected… and continue at very low rates.
- The idea of the student portfolio was abandoned due to the significant work involved and the perceived low value for assessment purposes.
- Program struggled with the evaluation process: how to relate the assessment and evaluation processes and cycles for PEOs and student outcomes.
- WORKLOAD: How to separate the valuable information from lots of data. Successful programs have discovered how to focus on a few but reliable assessment tools.

Georgia Tech's Mechanical Engineering Program Experience

- Have gone through three cycles using EC2000
- Learned more each time and have gotten much better at managing assessment and evaluation workload
- Have made minimal changes to our PEOs and have framed them in a way that we can measure them
  - Institute tools for alumni surveys and statistical baselines
  - Heavy engagement of advisory board
  - Alumni focus groups
  - Must remember to document what you do

Georgia Tech's Mechanical Engineering Program Experience

- Kept to the basic a-k ABET student outcomes
  - Did not innovate with student outcomes as was intended by the EC 2000 change
  - Employ sampling methods (5-6 courses per semester)
  - Developed a faculty tool for assessment of student mastery in selected courses
  - Use the Undergraduate Curriculum Committee to perform frequent evaluations of assessment data
  - Use institute resources for graduating senior exit surveys
- 2012 major curriculum change: 15 hours of free electives
  - Informed by the ASME 2030 Roadmap for mechanical engineering education
  - Enabled by ABET's EC 2000

THANK YOU!