A strategy for sustainable outcomes assessment for a large mechanical engineering program (that maximizes faculty engagement)

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Outline

• Background and context
• Student outcomes assessment needs
• Process description and implementation
• Summary, observations and opportunities
Mechanical Engineering at Iowa State University

Background and context
Iowa State University

- Public land-grant institution, established 1858
- One of the first universities established using the provisions of the Morrill Act
- Doctoral granting High Research Activity University
- Eight colleges with 30,000 students

- Top 50 public school
- Top 100 National University
- Ranks 2nd nationally in licenses and options executed on IP
College of Engineering

• Eight departments delivering 12 engineering programs
• Ranked nationally in the top 25% of engineering programs in public universities
• 6000 undergraduate and 1000 graduate students
• Undergraduate engineering program is one of the 10 largest in the US
• 226 tenured and tenure-track faculty, with 29 endowed chairs and professorships and 18 Distinguished and University Professors
Mechanical Engineering

- Most popular UG major on campus
- 1350 undergraduate students
  - 240 BSME degrees awarded annually
- 190 graduate students
Mechanical Engineering

- 36 tenure/tenure-track faculty and lecturers
  - 32.5 full time equivalents (FTEs)
  - 3 research center directors, 1 dean
- $14M research expenditures in FY 2011
- Student to faculty ratio ~ 40
- Teaching assistants primarily for lab courses and large enrollment sections. UG graders provided for large enrollment sections as well.
Curriculum

- Basic Program (26.5)
- Gen Ed (15)
- Math and Science (20)
- Core (50)
- Tech Electives (18)
Performing program assessment

Student Outcomes Assessment
# Nomenclature

<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Objectives</td>
<td>Statements that describe the expected accomplishments of graduates during the first few years after graduation.</td>
</tr>
<tr>
<td>Outcomes</td>
<td>Statements that describe what students are expected to know and able to do by the time of graduation.</td>
</tr>
<tr>
<td>Criteria</td>
<td>Specific, measurable statements identifying the performance(s) required to meet the outcome; confirmable through evidence.</td>
</tr>
<tr>
<td>Assessment</td>
<td>Processes that identify, collect, use and prepare data that can be used to evaluate achievement.</td>
</tr>
<tr>
<td>Evaluation</td>
<td>Process of reviewing the results of data collection and analysis and making a determination of the value of findings and action to be taken.</td>
</tr>
</tbody>
</table>
ABET general criterion 4: Continuous Improvement

- The program must regularly use appropriate, documented processes for assessing and evaluating the extent to which both the program educational objectives and the student outcomes are being attained.
- The results of these evaluations must be systematically utilized as input for the continuous improvement of the program.
- Other available information may also be used to assist in the continuous improvement of the program.

ABET Engineering Accreditation Commission, 2012-13 Engineering Programs Criteria
ABET Criterion 3: Student Outcomes

Student outcomes are outcomes (a) through (k) plus any additional outcomes that may be articulated by the program.

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.
Mechanical Engineering program criteria (ASME)

1. Curriculum: The program must demonstrate that graduates have the ability 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 work professionally in both thermal and mechanical systems areas.
Outcomes assessment needs

Student vs. Program assessment

• Student assessment is precise and done for ALL students
• Program assessment is broad and can be done on representative samples
  • Representative sampling is acceptable and desirable for programs of large size

Formative vs. Summative assessment

• For purposes of accreditation, summative assessment is necessary
Direct and Indirect Assessments

- It is important to use both direct and indirect assessment tools

<table>
<thead>
<tr>
<th>Method</th>
<th>Direct</th>
<th>Indirect</th>
<th>Method</th>
<th>Direct</th>
<th>Indirect</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exit and Other Interviews</td>
<td></td>
<td>✓</td>
<td>Locally Developed Exams</td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td>Simulations</td>
<td>✓</td>
<td></td>
<td>External Examiner</td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td>Behavioral Observations</td>
<td>✓</td>
<td></td>
<td>Written Surveys, Questionnaires</td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td>Archival Data</td>
<td></td>
<td>✓</td>
<td>Portfolios</td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td>Focus Groups</td>
<td></td>
<td>✓</td>
<td>Oral Exams</td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td>Performance Appraisal</td>
<td>✓</td>
<td></td>
<td>Standardized Exams</td>
<td></td>
<td>✓</td>
</tr>
</tbody>
</table>
Challenges

- Direct assessment tools are typically more time/effort intensive
- Faculty are in best position to perform direct assessment
- Faculty engagement is critical
  - Misconceptions on requirements/needs
  - Accountability and responsibility
  - Priority – time and effort constrained
  - Notion of ‘additional burden’
Outcomes assessment in ISU-ME

Process description
Oversight process – 2006/07

- CDC
- MECC
- MEASAC
- PICC
- Lab Committee
- Grad Studies Committee

**Abbreviations**
- **PICC**: Program improvement Coordinating Committee.
- **MECC**: ME Curriculum Committee (MECC).
- **MEASAC**: ME Academic Standards and Assessment Committee.
- **MEGSC**: ME Graduate Studies Committee (MEGSC).
- **CDC’s**: Course Development Committees.

- ➡️ Program Objectives Data
- ⬅️ Programs Outcomes Data
Direct assessment Processes

Instruments

- Course outcomes assessment (direct)
  - Performed for every outcome in every course offered, every semester
- Design Panel (direct)
  - Faculty and advisory board members assess samples of design reports

Observations

- Time and effort intensive for faculty
- Large amounts of data
- Faculty engagement was difficult
## Snapshot of assessment and evaluation process – 2006/07

<table>
<thead>
<tr>
<th>Fall Semester</th>
<th>Spring Semester</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Assessments:</strong></td>
<td></td>
</tr>
<tr>
<td>• Design</td>
<td></td>
</tr>
<tr>
<td>• Student</td>
<td></td>
</tr>
<tr>
<td>• Graduating senior</td>
<td></td>
</tr>
<tr>
<td>• Alumni (biennial)</td>
<td><strong>Assessments:</strong></td>
</tr>
<tr>
<td>• Student</td>
<td></td>
</tr>
<tr>
<td>• Graduating senior</td>
<td></td>
</tr>
<tr>
<td><strong>Actions:</strong></td>
<td></td>
</tr>
<tr>
<td>• CDC receives <em>Assessment Report</em> for previous semester</td>
<td></td>
</tr>
<tr>
<td>• CDC prepares improvement plan for next calendar year and submits as <em>CDC Plan</em></td>
<td></td>
</tr>
<tr>
<td>• MECC reviews plans, negotiates changes with the CDCs, and prepares an annual <em>Continuous Improvement Report</em> describing changes to the curriculum.</td>
<td><strong>Actions:</strong></td>
</tr>
<tr>
<td>• CDC receives <em>Assessment Report</em> for previous semester</td>
<td></td>
</tr>
<tr>
<td>• Design CDC meets with industrial advisory board to discuss changes</td>
<td></td>
</tr>
<tr>
<td>• All CDCs make changes to courses, which are implemented the following fall semester</td>
<td></td>
</tr>
<tr>
<td>• MECC presents annual <em>Continuous Improvement Report</em> to the faculty</td>
<td></td>
</tr>
</tbody>
</table>
Requirements for a sustainable direct outcomes assessment process

Requirements

• Focused data collection (more data are not always better) with aim of summative assessment

• Minimize burden on faculty

Path

• Spread and focus the effort across core courses (we do not have to measure everything in every course)

• Align direct assessment efforts with faculty effort in courses

• Spread assessment/evaluation across time (we do not have to evaluate everything every year)

• Tighten the oversight structure
Fall 2010 – oversight process

- Associate Chair for Undergraduate Studies
  - Responsible for continuous improvement and accreditation efforts
  - Communicate needs and requirements to faculty
- Chairs a single committee with oversight of undergraduate education (UGEC)
  - Program assessment, evaluation, recommendations to the faculty
  - Leverages existence of Course Development Committees for our core courses
  - Chairs of committees on the UGEC
Course Development Committees

- ME 160/170 – Introduction to Engineering, programming and graphics CDC (1)
- ME 231/332 – Thermodynamics CDC (1)
- ME 270/Capstone Design* – Design CDC (2)
- ME 324 – Manufacturing (1)
- ME 325 – Machine Design (1)
- ME 335 – Fluids (1)
- ME 370 – Engineering Measurements and (1)
- ME 421 – Dynamics and Control (1)
- ME 436 – Heat Transfer (1)
Aligning faculty instructional efforts with assessment efforts

- Use the notion of ‘embedded assessment’
- Utilize specific evaluative elements of a course towards direct assessment (not entire grade)
- Ensure all instructors of a course ‘are on the same page’
Program objectives to course outcomes
Action items

• Tasks to CDCs: Identify minimum set of course outcomes that are most important to all instructors – consequently content WILL be covered by ALL instructors
  • Different instructors can have different specific outcomes in addition to the above for their class, however a minimum set is needed for purposes of program assessment
• Map the course outcomes to student outcomes
• Identify ‘priority’ outcomes for each course: Rank order the mapped outcomes to reflect perceived importance of ALL instructors – consequently content will be delivered by ALL instructors
### Example: ME 370 - Engineering Measurements

<table>
<thead>
<tr>
<th>Course Outcome (below)/Program Outcome (right)</th>
<th>(a) An ability to apply mathematics, science, and engineering knowledge.</th>
<th>(b) An ability to design a system, component, or process to meet desired needs within realistic constraints.</th>
<th>(c) An ability to function on multidisciplinary teams.</th>
<th>(d) An ability to identify, formulate, and solve engineering problems.</th>
<th>(e) An understanding of professional and ethical responsibility.</th>
<th>(f) An ability to communicate effectively.</th>
<th>(g) The broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context.</th>
<th>(h) A recognition of the need for, and an ability to engage in, life-long learning.</th>
<th>(i) An ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Understand basic theory related to the engineering measurement process.</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Understand the role of sampling and signal conditioning in enhancing measurements.</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>3. Recognize a measurement system’s dynamic limitations by understanding first-order and second-order behavior, and to characterize frequency response.</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. Apply rigorous data treatment procedures such as statistical and error propagation methods to experimental results, thereby allowing objective and accurate data interpretation.</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. Synthesize theoretical knowledge to perform experiments and recognize practical aspects of engineering measurements.</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>6. Develop effective communication skills by engaging in verbal interaction with team members and by submitting succinct and descriptive written reports.</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>7. Appreciate measurement and instrumentation in the context of contemporary issues.</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td></td>
<td>X</td>
</tr>
</tbody>
</table>

**RANK ORDER**

1  2  6  8  3  7  9  4  5
# ME 325: Machine Design

## Course Outcome (below) / Program Outcome (right)

<table>
<thead>
<tr>
<th>Course Outcome</th>
<th>Program Outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td>(a) An ability to apply knowledge of mathematics, science, and engineering</td>
<td>(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, safety, legal, and societal factors</td>
</tr>
<tr>
<td>(b) An ability to design and conduct experiments, as well as to analyze and interpret data</td>
<td>(d) An ability to function on multidisciplinary teams</td>
</tr>
<tr>
<td>(e) An ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health, safety, legal, and societal factors</td>
<td>(f) An ability to identify, formulate, and solve engineering problems</td>
</tr>
<tr>
<td>(g) An ability to communicate effectively</td>
<td>(h) An ability to communicate effectively</td>
</tr>
<tr>
<td>(i) An understanding of professional and ethical responsibility</td>
<td>(i) An understanding of professional and ethical responsibility</td>
</tr>
<tr>
<td>(j) An ability to function on multidisciplinary teams</td>
<td>(k) An ability to function on multidisciplinary teams</td>
</tr>
<tr>
<td>(l) An ability to identify, formulate, and solve engineering problems</td>
<td>(m) An ability to identify, formulate, and solve engineering problems</td>
</tr>
<tr>
<td>(n) An ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health, safety, legal, and societal factors</td>
<td>(o) An ability to communicate effectively</td>
</tr>
<tr>
<td>(p) The broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context</td>
<td>(q) A recognition of the need for, and an ability to engage in life-long learning</td>
</tr>
<tr>
<td>(r) A knowledge of contemporary issues</td>
<td>(s) An ability to use the techniques, skills, and modern engineering tools necessary for engineering practice</td>
</tr>
</tbody>
</table>

1. The students will be able to apply failure theories to the design of machine components under various types of loads as well as single and combined loading modes.

2. The students will be able to identify the functional characteristics of various machine components and learn the design or selection process of individual machine elements such as gears, shafts and bearing.

3. The students will be able to evaluate alternate designs and apply design methodology.

4. The students will work in a team to appreciate the diversity of concepts, improve critical thinking, and communicate design results in written and/or oral reports.

5. Appreciate machine design in the context of contemporary issues and the interplay of technological, social, and political factors in resolving or exacerbating problems facing society.

| RANK ORDER | 5 | 1 | 3 | 2 | 4 | 4 | 6 |

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Iowa State University

Mechanical Engineering
Creating the direct (course) outcomes assessment map

• UGEC reviews all outcome maps and finalizes an outcomes assessment plan for program
  • Spread and focus the effort across core courses (we do not have to measure everything in every course)
  • Ensure all outcomes are being covered in accordance with Criterion 3 and ASME requirements
• Feedback and finalization
## Course outcome assessment map for program

<table>
<thead>
<tr>
<th>Student Outcomes</th>
<th>270</th>
<th>324</th>
<th>325</th>
<th>332</th>
<th>335</th>
<th>370</th>
<th>421</th>
<th>436</th>
<th>415/442/486</th>
</tr>
</thead>
<tbody>
<tr>
<td>(a) An ability to apply knowledge of mathematics, science, and engineering</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>(b) An ability to design and conduct experiments, as well as to analyze and interpret data</td>
<td>✓ (T)</td>
<td>✓ (M)</td>
<td>✓ (M)</td>
<td>✓ (M)</td>
<td>✓ (M)</td>
<td>✓ (M)</td>
<td>✓ (T)</td>
<td>✓ (T)</td>
<td>✓</td>
</tr>
<tr>
<td>(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</td>
<td>✓ (M)</td>
<td>✓ (T)</td>
<td>✓ (M)</td>
<td>✓ (M)</td>
<td>✓ (M)</td>
<td>✓ (T)</td>
<td>✓ (T)</td>
<td>✓ (T)</td>
<td>✓</td>
</tr>
<tr>
<td>(d) An ability to function on multidisciplinary teams</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>(e) An ability to identify, formulate, and solve engineering problems</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>(f) An understanding of professional and ethical responsibility</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>(g) An ability to communicate effectively</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>(h) The broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>(i) A recognition of the need for, and an ability to engage in life-long learning</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>(j) A knowledge of contemporary issues</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>(k) An ability to use the techniques, skills, and modern engineering tools necessary for engineering practice</td>
<td>✓</td>
<td>✓ (M)</td>
<td>✓</td>
<td>✓ (T)</td>
<td>✓</td>
<td>✓ (M)</td>
<td>✓ (T)</td>
<td>✓ (T)</td>
<td>✓</td>
</tr>
<tr>
<td>(ASME) The ability 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 work professionally in both thermal and mechanical systems areas.</td>
<td>✓</td>
<td>✓ (M)</td>
<td>✓</td>
<td>✓ (T)</td>
<td>✓</td>
<td>✓ (M)</td>
<td>✓ (T)</td>
<td>✓ (T)</td>
<td>✓</td>
</tr>
</tbody>
</table>

Incorporated into outcomes (a), (b), (c), (e) and (k) as indicated by thermal (T) and mechanical (M)

- ✓ indicates course outcome maps to student outcome
- ✓ indicates course will directly assess this particular outcome
The actual assessing - instruments

- Engage CDCs in developing specific direct assessment for each priority outcome
  - Align direct assessment efforts with faculty effort in courses
- Evaluate course outcomes
  - Determine activity, instrument and criteria for attaining an outcome
    - Simple outcomes can be evaluated using specific evaluative components
    - Complex outcomes can be evaluated using performance indicators and rubrics
Guiding the faculty

• Use an excel worksheet for data entry/collection
• Provide instructions and visual cues for data entry
(a) An ability to apply knowledge of mathematics, science, and engineering

4. Apply rigorous data treatment procedures such as statistical and error propagation methods to experimental results, thereby allowing objective and accurate data interpretation.

   **Activity Description:** Perform error analysis involving finite statistics and partial differential equations

   **Instrument:** Final Exam, Problems 7 and 8

   **Criteria:** > 14/20 points

   **Assessment Results:**
   - Sample size: 129
   - Met criteria: 95
   - % Successful: 74%

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

   **Activity Description:** Design and conduct an experiment associated with mechanical systems using available laboratory equipment

   **Instrument:** Lab 6 report, graded against rubric

   **Criteria:** Score > 80%

   **Assessment Results:**
   - Sample size: 129
   - Met criteria: 108
   - % Successful: 84%

(j) A knowledge of contemporary issues

3. Recognize a measurement system’s dynamic limitations by understanding first-order and second-order behavior, and to characterize frequency response.

   **Activity Description:** Describe the system behavior and signal characteristic

   **Criteria:** Score > 70%

   **Assessment Results:**
   - Sample size: 129
   - Met criteria: 121
   - % Successful: 94%

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**STEP 1:** Fill in Date and Instructor name

**FILL IN THE GREEN BOXES ONLY
WHITE BOXES ARE LOCKED**

**Assessment done by:** John Doe

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**IOWA STATE UNIVERSITY**

**Mechanical Engineering**
Faculty need to…

- Fill in excel sheet with requested data
- Identify course outcome that you are assessing (maps to ABET student outcome)
- Assess the course outcome based on an activity or evaluative component
  - Decide what instrument you are using to assess and provide a succinct description of activity and tool used for assessment
    - Exam, HW, lab, project, entire or particular question/component
  - Decide criteria for meeting performance
    - A score of 70% or more on question 2 in exam 1
    - A score of 75% on Lab 3
- Enter student sample size and number that met criteria
- Submit copies of sample student work for the instruments used for assessment
  - Excellent, average and poor (1 each)
## Example

**Course**  
ME 325  
Machine Design

**Date of Assessment**  
May 6, 2011

**Assessment done by**  
G S

<table>
<thead>
<tr>
<th>Student Outcome</th>
<th>Course Outcome</th>
<th>Activity Description</th>
<th>Instrument</th>
<th>Criteria</th>
<th>Assessment Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>(c) An ability to design a mechanical system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability</td>
<td>2. The students will be able to identify the functional characteristics of various machine components and learn the design or selection process of individual machine elements such as gears, shafts and bearing</td>
<td>Design teams are required to source and analyze machine components for a power train given constraints on factors of safety, reliability, stock sizes</td>
<td>Design calculations, drawings, narrated animation</td>
<td>Teams must score at least 75% of possible points on the design project</td>
<td>124</td>
</tr>
<tr>
<td>(f) An understanding of professional and ethical responsibility</td>
<td>5. Appreciate machine design in the context of contemporary issues and the interplay of technological, social, and political factors in resolving or exacerbating problems facing society.</td>
<td>An ethics case study was presented for analysis using ASME, NSPE codes of ethics</td>
<td>Written essay describing ethics violations and recommendations, graded against a rubric</td>
<td>Students must score at least 75%</td>
<td>114</td>
</tr>
</tbody>
</table>
Reporting data for evaluation

- Combine data for each student outcome
- Compare to target values for program
  - Target values established by faculty

- ‘Triangulation’ is important – multiple methods of assessing can help ensure validity of observations

- FE morning exam data – about 40% of graduating class take the exam (last 10 years)
- Online performance and learning tool (OPAL) – feedback from supervisors observations of intern/coop students
  - About 75-80% of graduating class participate in an internship or coop experience
## Example of evaluation

<table>
<thead>
<tr>
<th>Method of Assessment</th>
<th>Where data are collected</th>
<th>Year/semester of data collection</th>
<th>Target for performance</th>
<th>Summary of Evaluation Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Course Outcomes Assessment</td>
<td>ME 332, 370, 421</td>
<td>Fall 2011</td>
<td></td>
<td>Sample size range from 115 to 150 students (~65% of graduating class). 79% of students demonstrated outcome</td>
</tr>
<tr>
<td>Course survey</td>
<td>Online</td>
<td>Fall 2011</td>
<td>85%</td>
<td>A sample of 754 students (~67% of students enrolled in program) responded to survey. 89% of respondents indicated they were provided with the opportunity to demonstrate outcome.</td>
</tr>
<tr>
<td>FE Exam data</td>
<td>NCEES data</td>
<td>2006-2010</td>
<td></td>
<td>474 ME graduates took the exam in 2006-10 representing 46% of ME graduates during those years. Meet or exceed national score in Mathematics and Probability/Statistics components. The average ISU-ME score was 71% compared to national average of 71%. The difference is not statistically significant. The average ISU-ME score in Prob-Stat was 68% compared to the national average of 62%. This difference is statistically significant. In Thermodynamics, the average ISU-ME score was 64% compared to national average of 59%. The difference is statistically significant. In Chemistry, the average ISU-ME score was 71% compared to the national average of 68%. The difference is not statistically significant.</td>
</tr>
</tbody>
</table>
Current status and next steps

Summary, observations and opportunities
Timeline

Oversight structure change
Summer 2010

Identifying common/minimum set of course outcomes (faculty)
Fall 2010

Prioritized outcome mapping (faculty)
Fall 2010

Identify and address issues (all)
Spring/Summer 2011

Pilot
Spring 2011

Outcomes assessment plan for program (UGEC)
Fall 2010

Implement
Fall 2011, Spring 2012

Evaluate data (UGEC)
Spring 2012
## Benefits of the mapping exercise

<table>
<thead>
<tr>
<th>Issue identified during mapping</th>
<th>Curricular change to address issue</th>
</tr>
</thead>
<tbody>
<tr>
<td>No opportunity for all students to participate in a mechanical systems design experience AND thermal systems design experience</td>
<td>Implemented a design experience in a machine design course and heat transfer.</td>
</tr>
<tr>
<td>Almost all lab experiences focused on conducting experiments (specific instruction-driven) and analysis of data. There were no opportunities for students to design/construct their own experimental procedure.</td>
<td>Two inquiry-based laboratory exercises were designed and implemented in an engineering measurements class and a fluids class.</td>
</tr>
<tr>
<td>Difficulty in measuring competency in knowledge of contemporary issues</td>
<td>A specific exercise created in the engineering measurements class to visit state-of-the-art facilities on campus and learn about advances in engineering measurements, analysis and the broader problems they are being used to solve. Students write a report that is graded against a rubric.</td>
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<tr>
<td>Lack of focus on using modern engineering tools in thermal fluids classes</td>
<td>Heat transfer class incorporated analysis activities using computational fluid dynamics (CFD).</td>
</tr>
</tbody>
</table>
# ME 436: Heat Transfer

<table>
<thead>
<tr>
<th>Course Outcome (below)/Program Outcome (right)</th>
<th>(a) An ability to apply knowledge of mathematics, science, and engineering</th>
<th>(b) An ability to design and conduct experiments, as well as to analyze and interpret data</th>
<th>(c) An ability to design a system, component, or process to meet desired needs within realistic constraints</th>
<th>(d) An ability to function on multidisciplinary teams</th>
<th>(e) An ability to identify, formulate, and solve engineering problems</th>
<th>(f) An understanding of professional and ethical responsibility</th>
<th>(g) An ability to communicate effectively</th>
<th>(h) The broad education necessary to understand the impact of engineering solutions in a global, cultural, economic, societal, and environmental context</th>
<th>(i) A recognition of the need for, and an ability to engage in, life-long learning</th>
<th>(j) An ability to use the techniques, skills, and modern engineering tools necessary for engineering practice</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Understand and describe the three modes of heat transfer in the context of engineering applications.</td>
<td>x</td>
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<td>2. Understand conduction heat transfer and its application to steady-state and transient processes</td>
<td>x</td>
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<tr>
<td>3. Understand convection heat transfer that may include boundary layers, internal and external flows, forced and natural convection, and its application.</td>
<td>x</td>
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<tr>
<td>4. Understand radiation heat transfer and corresponding properties.</td>
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<tr>
<td>5. Synthesize the understanding of heat transfer principles into the performance analysis and design of heat exchanger devices.</td>
<td>x</td>
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<tr>
<td>6. Understand thermal sciences principles through the use of experimental techniques.</td>
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</table>

**RANK ORDER**

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<th>1</th>
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<th>3</th>
<th>4</th>
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<th>6</th>
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</thead>
<tbody>
<tr>
<td>3</td>
<td>2</td>
<td>1</td>
<td>4</td>
<td></td>
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</tr>
</tbody>
</table>
Summary and observations

- Mechanical Engineering at Iowa State University has undergone a process review and change for its direct assessment needs with a goal towards sustainability.
- The notion of a common/minimum set of course outcomes and a subsequent prioritized mapping to student outcomes helps in spreading the direct assessment effort across the curriculum.
- Using course outcomes helps align direct assessment efforts with instructional efforts.
- A tight oversight structure that facilitates efficiency of action and information flow.
- The use of a guided excel sheet facilitates faculty interpretation of requirements and data entry.
- Currently finalizing a staggered timeline for assessment and evaluation (2 or 3 year cycle).
Observations

- Faculty time for completing direct assessment for a course: 45 – 100 minutes
- Feedback from faculty is mostly positive
  - Have a better understanding of the role and benefit of outcomes assessment vs. course grades in evaluating student learning
  - Alignment of efforts appreciated
  - Some notion of uncertainty with respect to setting criteria for a given outcome
Opportunities for improvement

- Automating data collation from excel sheets
- Improving coverage of contemporary issues
- Standardizing the course syllabus (to list the minimum set of outcomes)
- Timely submission of data
References

• Gloria Rogers, ABET Assessment Workshop Materials, 2010 Fall Symposium, Baltimore MD
• http://www.abet.org/assessment-planning-resources/