Vision 2030
Creating the Future of Mechanical Engineering Education

Thomas Perry, P.E.
ASME Director Education & Professional Development

June 19, 2010
ASME Asia-Pacific District Operating Board
Sydney, Australia
ASME Center for Education

Board of Directors (16)

- ME Department Heads Executive Committee (MEDH) (15)
- MET Department Heads Executive Committee (MEDH) (11)
- Graduate Education & Research Committee (5)
- Educational Research & Innovation Committee (4)
- ASME Scholarship Committee (9)
- ASME Student Loan Committee (4)
- Ben C. Sparks Award Committee (5)

Vice President

Conferences & Leadership Summits

Grant Projects

ABET Board of Directors Representatives (3)
ABET Technology Accreditation Commissioners (3)
ABET Engineering Accreditation Commissioners (6)

Committee on Engineering Accreditation (CEA) (16)
Committee on Technology Accreditation (CTA) (7)

2010-11 ASME/ABET (439) Degree Programs (174) Program Evaluators

~230 Volunteers

ASME SETTING THE STANDARD
ASME Center for Education

Board of Directors

- ABET Accreditation (and related)
- Department Head Programs & Services
- Grant-Funded Projects
- Faculty Development
- Graduate Education
- Financial Aid
- Awards

Vision 2030 – ME Education
Gender Equity/Climate Study Projects

ME Education Conferences
Leadership Summits
Benchmark Studies
DH Forums
ME/MEDH Listservs

What is ABET?
ASME Degree Program Responsibility
Domestic & International Visits
ASME Program Evaluators

Tips for Tenure Workshops

ASME Scholarships
ASME Student Loans

Ben C. Sparks Award

Grad Teaching Fellowships
Grad Student/Post Doc Brochure
Grad Students’ Reception

Domestic & International Visits
ASME Program Evaluators

Setting the Standard

ASME
Vision 2030 – Mechanical Engineering Education Project (Phase I)

- ASME Foundation supported assessment of entry-level graduate skills and future needs in ME degree programs
- Data and recommendations from 100 ME departments and 1,000+ engineers & managers in industry
1. Background – Building on recent significant work
2. Grand Challenges & Opportunities – 21st century needs
3. Changes in Industry and the ME Profession – What ME’s should know and be able to do
4. Current Assessment of Mechanical Engineering Education
5. Recommended Curricula and Outcomes for 2030
6. Advocacy and Action Agenda for Academic Change
   - Academic Drivers/Impediments
   - Industry Drivers/Support
   - Government Drivers/Support
   - ASME Drivers/Support
7. Global Challenges, Opportunities and Leadership
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Background Thinking *(50,000 foot-level)*

- NAE, 2004, The Engineer of 2020
- NAE, 2005, Educating the Engineer of 2020
- NAE, 2008, Changing the Conversation
- NSF, 2007, The 5XME Workshop: Transforming ME Education and Research
- ASME, 2008 Global Summit on the Future of Mechanical Engineering
- Duderstadt, 2008, Engineering for a Changing World
- ASCE, 2008, Civil Engineering Body of Knowledge for the 21st Century
- CDIO Methods/Advocacy
Strategic Implications for:

Center for Education – ABET Accreditation activities, department head and faculty developments programs, honors & awards, even (conceivably) student financial aid

Center for Career & Professional Advancement – Early career engineer development, student design competitions & expositions, ME Today/PPC

Strategic Management – I-Show

Center for Public Awareness – Career Guidance information (eg. What is a Mechanical Engineer, ME/MET: Which Path will you choose?)

.....Others?
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V2030 Project Goals

- Make the research-based (or at least research-informed) case for change

- Recommend improvements to the mechanical engineering and technology education curricula

- Provide ME/MET graduates with the needed expertise for successful professional practice, and

- Develop engineering leadership to solve technical and societal challenges
Our Students are Creative and Inventive but not necessarily innovative.

“Innovation occupies our attention today because the solution of almost every major problem is thought to depend on innovation. How will we raise the quality of life for every citizen? The answer is through innovation.”

— Dan Mote, President, University of Maryland

We also need: the Implementation of Invention …… **Innovation**

**Innovation Requires Leadership**
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Drivers for Change

The Big Picture

15 Global Challenges facing humanity

1. Sustainable development
2. Clean water
3. Population and resources
4. Democratization
5. Long-term perspectives
6. Global convergence of IT
7. Rich-poor gap
8. Health issues
9. Capacity to decide
10. Peace and conflict
11. Status of women
12. Transnational organized crime
13. Energy
14. Science and technology
15. Global ethics

by the Millennium Project of WFUNA
www.millennium-project.org
Increased Professional Expectations

- Engineering expertise will be required at a higher level than “routine” engineering (*although large numbers of these engineers will continue to be needed*).

- Greater expertise in communications, innovation, leadership, and creativity will be required (*but these topics are not typically a significant part of engineering curricula*).

New Knowledge and the Blurring/Widening of Disciplinary Boundaries

- Complex ‘Engineered Systems, Multi-disciplinary Engineering, …

The Grand Challenges & Unsustainable Growth – Call for Engineering Leadership
About entry-level mechanical engineers ….

“Afraid to get hands dirty and learn how products are made and assembled’, ‘have never disassembled and reassembled anything substantial’ -**Practical experience**

‘Lack of ability to transfer engineering knowledge to practical problem solving’, ‘Knowing which problem to solve’, ‘Inability to get to the root of even basic problems’, ‘clueless as to what a reasonable answer should be to any computational question, instead they say – the computer says’ -**Problem solving**
Four ME Department Head Forums, 2008-2010

Three Surveys of ME Department Heads (1) and engineering managers in industry (2)

Total input to date MEDH’s from 100+ universities and over 1,000 engineering managers

U.S. only..... So far.
Q1. Job Function
Q2. Involved in hiring entry-level engineers?  
41% Yes, 59% No

Q3. Directly supervise entry-level engineers?  
50% Yes, 50% No
Q4. Assessment of entry-level ME skills

- Information processing (electronic communication)
- Computer modeling/analysis (software tools)
- Technical fundamentals (traditional ME subdisciplines)
  - Interpersonal/teamwork
  - Problem solving & critical thinking (analysis)
  - Communication (oral, written)
- New technical fundamentals (new ME applications)
  - Design (product creation)
  - Experiments (laboratory procedures)
- Practical experience (how devices are made/work)
  - Leadership
- Overall systems perspective
- Engineering Codes and Standards
  - Project management
  - Business processes

Not important for entry-level
Weak - needs strengthening
Strong
Weak - but not an entry-level concern
Sufficient. No Concerns
Strong - but needs even more emphasis
Q4. Assessment of entry-level ME skills
### Q4. Industry Assessment of entry-level ME skills

#### Q4. MEDH Assessment of BSME Curricula

(Note: Some values do not add to 100%; some respondents failed to provide a valid response)
## ASME Center for Education

### V2030 Industry/Academic Comparison

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<thead>
<tr>
<th>Category</th>
<th>Good – no concern</th>
<th>Weak – needs strengthening</th>
<th>Sufficient. No Concerns</th>
<th>Strong</th>
<th>Strong – needs more emphasis</th>
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<tbody>
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<td>Overall systems</td>
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<td>Pragmatic experience</td>
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<td>Technical fundamentals</td>
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<td>New technical areas</td>
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<td>Practical experience (devices made/work)</td>
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<tr>
<td>Problem solving &amp; critical thinking &amp; analysis</td>
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<td>Project management</td>
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<thead>
<tr>
<th>Category</th>
<th>3%</th>
<th>14%</th>
<th>45% (47%)</th>
<th>34% (32%)</th>
<th>4% (16%)</th>
<th>1%</th>
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<td>Overall systems</td>
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<tr>
<td>Practical experience</td>
<td>1%</td>
<td>9%</td>
<td>59% (33%)</td>
<td>23% (41%)</td>
<td>6% (23%)</td>
<td>2%</td>
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<td>Problem solving &amp; critical thinking &amp; analysis</td>
<td>1%</td>
<td>3%</td>
<td>36% (7%)</td>
<td>44% (33%)</td>
<td>14% (59%)</td>
<td>3%</td>
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<td>Project management</td>
<td>12%</td>
<td>27%</td>
<td>33% (29%)</td>
<td>24% (44%)</td>
<td>3% (15%)</td>
<td>1%</td>
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<td>Technical fundamentals</td>
<td>0.3%</td>
<td>1%</td>
<td>20% (3%)</td>
<td>53% (29%)</td>
<td>22% (68%)</td>
<td>3%</td>
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<td>New technical areas</td>
<td>21%</td>
<td>15%</td>
<td>14% (40%)</td>
<td>40% (33%)</td>
<td>7% (6%)</td>
<td>0.5%</td>
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Q. If you foresee significant curricular changes, these would generally be accommodated by:

- Reduced electives: 12%
- Additional required courses: 28%
- Increased learning productivity using instructional technologies: 43%
- More efficient curricular planning: 75%
Barriers to change...

- Faculty availability (no time)
  - Not a barrier: 0%
  - Moderate barrier: 50%
  - Significant barrier: 50%

- Faculty availability (short staffed)
  - Not a barrier: 10%
  - Moderate barrier: 50%
  - Significant barrier: 40%

- Funding (insufficient)
  - Not a barrier: 20%
  - Moderate barrier: 60%
  - Significant barrier: 20%

- Faculty expertise (lacking)
  - Not a barrier: 30%
  - Moderate barrier: 40%
  - Significant barrier: 30%

- Faculty buy-in (resistance to change)
  - Not a barrier: 50%
  - Moderate barrier: 30%
  - Significant barrier: 20%

- Administration Support (lacking)
  - Not a barrier: 60%
  - Moderate barrier: 20%
  - Significant barrier: 20%

- ABET Accreditation (too restrictive)
  - Not a barrier: 40%
  - Moderate barrier: 50%
  - Significant barrier: 10%
Many choices for curricular structures

- Business as usual, with occasional introduction of new topics;
- The professional school model;
- A more flexible bachelor’s degree with additional content at the master’s level;
- A pervasive practice-based curriculum with CDIO emphasis;
- A broader, multi-disciplinary and flexible curriculum meeting the general ABET criteria but no disciplinary program criteria;
- An engineering curriculum that integrates content, including the humanities and social sciences, and pervasive communication skills;
- A engineering systems-focused curriculum;
- A curriculum emphasizing globalization, quality of life issues, and solving society’s grand challenges;
- A curriculum emphasizing the business of engineering, leadership, entrepreneurship, innovation and creativity........
ASME Center for Education
Univ. of Michigan 5XME Sample #1

Social Science
- Arts
- Humanity
- Business
- Economics
- Cultural Diversity
- Communication
- Interpersonal Psychology
- Elective

Problem Solving and Design
- Inverse Engineering
- Design concepts
- Systems engineering
- Case studies
- Modeling and simulation
- Research based
- 2 Capstone

BS 4 yrs. - 128 Credits

- Social Science; 25%
- Basic Science; 25%
- Problem-based and Design, 25%
- Core Engineering; 25%

Basic Science and Math
- 4 Math
- 2 Physics
- 1 Chemistry
- 1 Biology

Core Engineering
- 1 Mechanics
- 1 Electronics
- 1 Transport
- 1 Materials
- 1 System and Controls
- 1 Instrumentation, measurements & interface
- 2 Elective
BSME: 4 year, 120 (semester) credits

- **Basic Math/Science/Engg. Sci.** (25%)
- **Gen. Ed.** 12.5%
- **Prof. Dev.** 12.5%
- **ME Basic Core** 25%
- **Electives** 25%

**General Education**
Language, History, Political Science, Economics

**Professional Dev.**
Communication, Business/Marketing, Ethics, Global persp. etc.

**Electives:**
Can identify ‘tracks’ based on student career focus e.g. ME, Medicine, Technical Mgt. etc.
strengthening the ‘practical experience’ component of the students’ skill set,

a significant portion of the curriculum needs to be dedicated to such activities.

In this case, the ME curriculum should contain a design/professional spine with significant design-build
• Professional skills such as problem solving, teamwork, leadership, entrepreneurship, innovation, and project management would be central features of the design spine.

• These skills should be learned in the context of a structured approach to problem solving - problem formulation, problem analysis, and solution.
Incorporation of Grand Challenges into Design Spine

- ‘Grand Challenges’ can be incorporated as elements into the early design courses
- Provides a context and engineering background for students
- Indicates areas where mechanical engineers are needed to provide leadership in the development of innovative and sustainable solutions.
- Seven challenges relevant to mechanical engineering students:
  - the environment,
  - energy,
  - health,
  - security,
  - multi scale systems, and
  - global collaboration.
  - quality of life
• Year 1 – problem solving course, engineering computer graphics course
• Year 2 – product manufacturing course, design process course
• Year 3 – product development course
• Year 4 – two semester capstone senior design

• Reinforce the design/ professional topics are year by year, with no gap in the sophomore and junior years,
• All of the courses would incorporate group projects, teamwork, oral and written communication.
• Implementation will require both intellectual and financial resources: buy-in from the faculty, increased industrial expertise and support, increased workshop, laboratory and design studio space.
• ASME Survey of Early Career Engineers (self assessment)
• Go Global (International Validation)
• Further develop MET and the graduate curricula implications
• Disseminate desired practices & advocate support (ABET, Industry, Government, ASME)
• Lead and support the change efforts of departments
• Obtain funding for outcomes assessment for recommendations
• And…. Center for Education/IAB collaboration
Discussion.....