ASME Vision 2030

Designing the Future of Mathematical Engineering Education

Dr. Allan Kirkpatrick,
Professor and Past Department Head
Mechanical Engineering Department
Colorado State University
Fort Collins, CO

ASEE College Industry Education Conf.
Phoenix, Arizona
February 6-8, 2013
Outline of Presentation

• Background – *Drivers for change in ME education*

• ASME Vision 2030 Task Force - *survey assessment of ME education by industry, educators, graduates*
  – *Areas of strength and weakness*
  – *Recommendations for ME programs*
Drivers for change

• Increased Professional Expectations
  – Increased engineering expertise will be required and must incorporate non-technical skills and expertise.
  – Capability related to creativity, innovation, and leadership will be required to a much larger degree.
• **Globalization of Engineering Education**

  – There is an open, world-wide competition for the best mechanical engineering students and engineering professionals.
  – Mechanical engineers are expected to work globally with a variety of societies and cultures.
Global challenges of designing and delivering energy, water and food via sustainable development are becoming even more pressing for all engineering disciplines.
• Accreditation Board for Engineering and Technology (ABET)

• In 1996, Accreditation Board for Engineering and Technology (ABET) approved ‘Engineering Criteria 2000’

• Programs must formulate a set of overall educational objectives that are responsive to the needs of program constituents,

• Programs must also formulate a set of educational outcomes that address the objectives and also encompass a set of eleven (a-k) ABET outcomes. Divided into “technical skills” and “professional skills”
Discipline Specific Outcomes?

- ABET a-k outcomes are general as they span all engineering disciplines.
- In response, various professional societies instituted studies of specific outcomes for their discipline.
- For example, in 2006, the American Society of Civil Engineers developed ‘The Body of Knowledge for Civil Engineering’.
Mechanical Engineering Specific Outcomes?

- What are specific educational outcomes that would be meaningful to the employers and the mechanical engineering profession?
- How do these outcomes rank in importance?
- How well do our students achieve these outcomes?
ASME Response – Vision 2030

In 2008, ASME Vision 2030 Task Force was created to:

• assess the state of ME education,
• provide specific recommendations for improving mechanical engineering education curricula, and
• advocate for their adoption.
Vision 2030 Task Force

- Robert Warrington, Chair
- Allan Kirkpatrick, Editor
- Scott Danielson, Editor
- Alice Agogino
- Karen Thole
- Bill Wepfer
- Galip Ulsoy
- Cynthia Stong
- Richard Smith
- Steve Wendel
- Roxanne Engelstad
- Frank Kulacki
- Joe Sussman
- Bob Laurenson
- Tom Perry

Michigan Technology Institute
Colorado State University
Arizona State University
Univ of California - Berkeley
Penn State University
Georgia Technology Institute
Michigan State University
Boeing
National Science Foundation
Sinclair Community College
University of Wisconsin
University of Minnesota
Deloitte & Touche
Boeing (ret)
ASME
First, we needed data -- Vision 2030 task force asked the major constituencies about their desired program outcomes:

Employers who hire our students
Faculty who teach our students
Early career mechanical engineers

Current literature on engineering education was reviewed to build on past recommendations.
Building on past recommendations, for example --

- ASCE, *Body of Knowledge*, 2008


- *Educating Engineers: Designing for the Future of the Field*, Sheppard et al., 2009
Assessment of ME Education

• Workshops, Seminars at ASME Engineering Education Conferences, (2008-2011)

• Surveys of Academic, Industrial, Early Career Engineers
  
  • Initial survey used opened-ended response to strengths and weakness questions: ME Department Heads (n = 79) & Industry Supervisors (n = 381)

  • Responses were sorted into categories which best organized them

  • A second survey asked specific questions probing issues raised by the response categories.
- These surveys received an excellent response: Academic (n = 80 faculty), Industry (n = 1500 firms), Early Career Mechanical Engineers (n = 635).

- This assessment of ME education by industry engineering supervisors, early career mechanical engineers and academics provides a strong feedback mechanism to help us decide how to change and improve our ME programs.
• The median number of employees of global firms represented in the study is ~10,000.
• Wide range of global industry size -- approximately 5% of the firms had 50 or less employees worldwide.
• Approximately 5% of the firms had 100,000 or more employees worldwide.
Survey results show a wide range of opinion with regard to recent graduates’ “strengths!”
Greatest Strengths of Graduates

Industry supervisors rated these attributes of mechanical engineering education graduates as either sufficient or strong.
Survey results also illustrate significant weaknesses graduates’ skill set!
Perspectives of Constituents Vary

As seen above, there are different perspectives of graduate strengths and weaknesses across the survey groups of academic, industry supervisors, and early career engineers.

We will look at several of these cases in more detail.
Comparison Data for Problem-Solving Ability:
*Industry supervisors rated this as a more pervasive weakness of the recent graduates relative to other respondents.*

![Bar chart showing different perceptions of BSME preparation for problem solving](chart.png)
Comparison Data for Communications Skills: Significant difference in opinion between industry supervisors and educators / early career engineers

Different Perceptions of BSME Preparation: Communications Skills

- Supervisors: 43% "sufficient/strong", 52% "weak"
- Educators: 65% "sufficient/strong", 22% "weak"
- Early Career ME: 75% "sufficient/strong", 17% "weak"
Comparison Data for New Technical Fundamentals: Are industry supervisors more focused on immediate business-related needs?

Different Perceptions of BSME Preparation: New Technical Fundamentals (bio, nano, etc.)

<table>
<thead>
<tr>
<th>Supervisors</th>
<th>Educators</th>
<th>Early Career ME</th>
</tr>
</thead>
<tbody>
<tr>
<td>7% &quot;strong&quot;</td>
<td>5% &quot;strong&quot;</td>
<td>11% &quot;strong&quot;</td>
</tr>
<tr>
<td>14% &quot;weak&quot;</td>
<td>40% &quot;weak&quot;</td>
<td>30% &quot;weak&quot;</td>
</tr>
</tbody>
</table>
For purposes of improvement, it is useful to focus on perceived weaknesses of graduates.

The following data reflect the views of hundreds of engineering supervisors and early career engineers.
Engineering Supervisors: Areas of largest weaknesses

- Practical experience (how devices are made/work): 55.5%
- Communication (oral, written): 48.4%
- Engineering Codes and Standards: 46.9%
- Overall systems perspective: 44.3%
- Project management: 34.6%
Early Career Engineers: Areas with largest weaknesses

- Engineering Codes and Standards: 54%
- Practical experience (how devices are made/work): 42%
- Project management: 35%
- Business processes: 34%
- Overall systems perspective: 31%
- New technical fundamentals (bio, nano, info, etc.): 30%
The early career engineer survey data provide both a view of their education in our programs as well as areas of opportunity if interested in providing professional development opportunities.
Early Career Engineers: Perceptions of Professional Development Needs

Areas of greatest need for Professional Development

Ratings 8, 9, or 10 on scale of 1-10 (n~587 Early Career respondents)
Recommendations

• Work towards more balance of faculty skills within a program (practice AND research based faculty)
• Provide increased curricular flexibility
• Encourage richer practice-based engineering experiences for students
• Include more focus on innovation and creativity
• Work to develop students’ professional skills to a level equal to their technical skills
• Work to create greater diversity among students and faculty
Professional Practice

• Increase faculty expertise with respect to professional practice
  – Use ‘Professor of Practice’ concept to incorporate professors with industry experience in product realization, management, etc into an ME program.
  – Create opportunities for faculty development related to industry practice, e.g., faculty internships in industry.
ASME is initiating programs to increase faculty expertise with respect to professional practice

- Developing a two pronged approach to support the ‘Professor of Practice’ concept

- Approach: Develop a program to help fund tenured faculty internships in industry.

- Approach: Develop background case supporting and advocate for hires that are valued as industry-experienced faculty with title of “Professor of Practice.”
Curricular Flexibility

- Provide increased curricular flexibility
  - A way to incorporate new applications and emerging technologies into the curricula
  - Separate engineering curricula into ‘core’ and ‘concentration’ areas
  - ASME is working with ABET to change the ME Program Criteria to allow more flexibility for students to choose capstone project work in either mechanical or thermal systems
Practice-based Engineering

• Richer practice-based engineering experience for students
  – Increase applied engineering design-build-test experiences throughout degree program
  – Increase familiarity with how devices are made and work
  – More exposure to codes and standards
  – More pervasive systems perspective
Importance of Practice-based Experience

• Desired: Increase the student’s practice-based experience

• How can that be done?

A significant portion of the curriculum needs to be dedicated to such activities!

• The ME curriculum should contain a design/professional spine.
Innovation and Creativity - Design Spine

- Design and build project classes every year or semester
- Prepare students for year-long senior capstone design projects, requiring increased complexity and scope.

Year 2 – small scale

Year 4: large scale
Senior Capstone Project

• ABET accreditation requires a ‘capstone’ experience integrating knowledge and skills learned in the program.

• ASME has developed a wide variety of successful competition-based design projects.

• Such a Capstone Design/Build/Test course can help students obtain practical experience and upgrade their professional skills.

• Projects are best if students not only have to design, build, but also test their device.
Professional Skills

- Develop students’ professional skills to a higher standard
- Communication, problem solving, ethics, entrepreneurship, project management, interpersonal skills, leadership, and teamwork
ASME Vision 2030 publications

Questions?

For PDF format of copies of various Vision 2030 Phase documents, contact

Thomas J. Perry, P.E.
Director, Education & Professional Advancement,
ASME, perryt@asme.org

Dr. Scott Danielson, P.E.
Associate Dean, Arizona State University
Scott.Danielson@asu.edu

Dr. Allan Kirkpatrick, P.E.
Professor, Mechanical Engineering
allan@engr.colostate.edu