Creating the Future of Mechanical Engineering Education  
An Action Agenda for Educators, Industry, and Government  

ASME Board on Education  
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What mechanical engineers do, and how they do it, constantly changes as boundaries of the discipline expand and professional expectations increase to serve an increasingly global marketplace. ASME’s Vision 2030 project (V2030) analyzed the perspectives of recent engineering graduates, their professors and their employers along with recent engineering education studies to offer recommendations on how mechanical engineers should be educated to meet the demands of their transforming profession as well as the grand societal challenges of the future.

What should Mechanical Engineering education look like in 2030? Seven aspects of the educational landscape emerge as target areas for change. They encompass a wide range, spanning the educational pathways of mechanical engineering and mechanical engineering technology to the increasingly diverse practice of mechanical engineering. To affect these changes, what specific strategies can educators, industry, and government pursue? The following actions are urged for seven major outcome areas of curricular change:

**RICHER PRACTICE-BASED EXPERIENCE**

*Action:* Offer more authentic practice-based engineering experiences such as the design spine or design portfolio approach.

Among the greatest weaknesses noted among current ME and MET graduates by their employers, as well as the early career engineers themselves, are a lack of practical experience in how devices are made or work, a lack of familiarity with industry codes and standards, and a lack of a systems perspective. To address these weaknesses, an increase in and enrichment of applied engineering design-build experience throughout degree programs is urged.

**STRONGER PROFESSIONAL SKILLS**

*Action:* Develop students’ professional skills to a higher standard.

Both industry supervisors and early career engineers emphasize that graduates need stronger professional skills, e.g., interpersonal skills, negotiating, conflict management, innovation, oral and written communication, and inter-disciplinary teamwork. To meet this need, a systematic focus on integration of such skills into curricula must approach the priority given to technical topics. Incorporation of a multi-year design spine, or portfolio approach, which incorporates such skills development integrated with technical competency development into curricula, is urged.
MORE FLEXIBLE CURRICULA

Action: Create curricular flexibility and efficiency with core requirements and specialization options.

To enable students to develop understanding of mechanical engineering fundamentals but also offer greater strength in context and realization of design, a better systems perspective, and the possibility of focus in an area of interest, there is a need for greater flexibility in the degree path. Thus, the model of a required ME “core” set of fundamental classes, followed by a concentration area is suggested, echoing recommendations of earlier studies.

GREATER INNOVATION & CREATIVITY

Action: Create a curriculum that inspires innovation and creativity.

The chance to produce practical and technical innovation to solve real world problems and to help people is one of the most inspiring aspects of the profession to prospective or young engineers. Developing student creativity and innovation skills, through explicit curricular components that emphasize active, discovery-based learning – such as a design spine or portfolio, or other authentic extracurricular engineering experiences -- can also enhance motivation and retention. Faculty members who can mentor and coach students through these experiences are also needed.

TECHNICAL DEPTH SPECIALIZATION

Action: Focus on post graduate education for specialization

Additional technical depth and specialization in mechanical engineering topics, plus increasingly sophisticated professional skills, will be required in many aspects of industry, according to both department heads and industry managers. The growing availability of professional Master’s degrees provides increased opportunity for graduates and practitioners to meet such a need.

NEW BALANCE OF FACULTY SKILLS

Action: Increase faculty expertise in professional practice.

To produce graduates with the practical and professional skills described above, diversification of faculty capabilities is required. Employing more faculty members with significant industry experience and creating continuous faculty development opportunities for exposure to current industry practice is urged. Faculty with experience in product realization and innovation, project management and business processes, with understanding of the use of codes and standards in different contexts will impart a greater and more authentic sense of the world of practice to students.

Action: Modify ABET program criteria regarding student competencies.

To enable curriculum change and encourage more flexible curricula, modifications to program criteria for ME and MET, e.g., no longer requiring equal thermal and mechanical competencies, but preparation for professional work in one or the other, with exposure to the area not emphasized, are recommended.

Action: Modify ABET ME program criteria for faculty numbers and qualifications.

ABET ME Program Criteria should address metrics for minimum faculty size and student to faculty ratio to ensure program quality in design and also address measures that increase the proportion of practice-experienced faculty.
Background: The Case for Change

These recommendations represent the findings of an ASME Board on Education task force appointed in 2009. The task force was charged with defining the knowledge and skills that mechanical engineering and mechanical engineering technology graduates should have to be globally competitive and with advocating for adoption of recommendations for mechanical engineering curricula with the goal of better preparing graduates to meet the demands of a transforming professional environment.

The task force finds many reasons to advocate for fundamental changes in mechanical engineering education. Arguments for change come from recent engineering education studies, analyses of the engineering profession and unique to this study, extensive current surveys of academia, industry, and early career engineers. Major findings of the full V2030 report include:

- **Society’s grand challenges**, as articulated by the National Academy of Engineering, offer a compelling reason for substantial curricular change: to better equip mechanical engineering graduates to confront those challenges, not only with a solid technical foundation, but also with creativity, strong professional skills, and leadership within engineering and society.

- In a global setting, industry must be successful and able to create **sustainable growth**. To do so, companies large and small must have a talented and well prepared engineering workforce. In the coming decades, and “well prepared” will mean something more than in the late 20th Century.

- According to nearly two-thirds of the over 1,000 industry managers surveyed by the V2030 task force, **entry level mechanical engineers need strengthening in how devices are made and work and in communication skills**. Other significant shortcomings exist in graduate’s grasp of **engineering codes and standards and systems thinking**.

- **Technical solutions are not enough**. The roles to be played by mechanical engineering professionals in addressing business and societal challenges should not be limited to technical solutions! The engineering profession has an obligation to see that technology is implemented in viable economic, social and environmental terms. Engineering leadership will be required in the workplace and in other social arenas as well.

- Mechanical engineer’s capacity for invention must be matched by a **commitment to all aspects of innovation**. Future innovation will require assessment of sustainability, life-cycle analysis, and other societal impacts. Such knowledge and abilities will aid companies, non-profit organizations and government in many positive ways.

- Developing a technological workforce that can **maximize the leverage of talent** demands a priority on increasing the diversity of the mechanical engineering student body and faculty.

- **Industry, academia, government and professional societies need sustained and focused collaboration** in order to develop the full potential of engineering and engineering leadership, and to best effect the recommendations of the task force.
Compelling challenges face society, governments and businesses. Mechanical engineering graduates are a critical resource in providing solutions to meet demands of sustainable wealth creation and resource utilization, enabling successful companies in local and global settings, and leading solutions of the world’s grand challenges. Successfully meeting these challenges requires change in our mechanical engineering educational system to better enable the success of graduates through the span of their career, either in engineering or in related fields.

**Approach and Method**

The rationale and recommendations described above represent the perspectives of hundreds of stakeholders in ME and MET education, working through the ASME Vision 2030 task force, and surveyed in 2009 and 2010.

Started in July 2008, when the ASME Center for Education formed an engineering education task force, the Vision 2030 group has been led by representatives from industry and education, including engineering and engineering technology educators.

The project investigated the current state of mechanical engineering education and practice within industry through assessment of recent literature addressing the shape and content of engineering and engineering technology education and through conducting workshops among stakeholders at key conferences and gatherings. Events included the ASME International Mechanical Engineering Education Conference (2009, 2010, 2011), the ASME International Mechanical Engineering Conference and Exposition (2009, 2010, 2011), the University of Houston’s Engineering Technology Summit (2010), the annual meeting of the American Society for Engineering Education (2010), and the 5XME workshop sponsored by the US National Science Foundation (2009).

To develop its recommendations, the project identified key areas of knowledge, skills and abilities needed for mechanical engineering and mechanical engineering technology graduates to be successful in a global economy, whether working in small companies or large. Focusing on these key skills, the project developed and conducted extensive surveys in 2009 and 2010 of three key stakeholder groups in ME and MET department heads, industry supervisors, and early career engineers, to assess the strengths and weaknesses of mechanical engineering education graduates. Responses were received from academic leaders at more than 80 institutions, from more than 1,400 engineering managers, and more than 600 early career engineers with less than ten years of practice.

The recommendations of the Task Force and subsequent ASME support and advocacy over the next several years is intended to shape the educational landscape of mechanical engineering education, especially its mechanical engineering and mechanical engineering technology programs, for the coming decades. It will take the combined efforts of educators and administrators, professional societies, employers, industry leaders and state and federal governments to ensure that mechanical engineering education pathways and partnerships are sufficiently robust and flexible to produce graduates capable of meeting the challenges of our technologically changing world and the grand challenges facing our planet.

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