The Implications of ASME Vision 2030 for Mechanical Engineering Programs

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Abstract

The American Society of Mechanical Engineers (ASME) is nearing the conclusion of *Vision 2030*, a multi-year effort to define the future of mechanical engineering education. The society has surveyed over 1000 employers of mechanical engineers and involved many industry representatives in this effort to determine what important skills a mechanical engineer will need in the year 2030. The recommendations of *Vision 2030* include significant, broad changes to mechanical engineering education at the undergraduate and graduate levels. They also bring to light the dualistic nature of engineering education, with faculty and courses focused either on the practice of engineering, or on an academic research-oriented approach to engineering. This paper discusses the potential effects of the recommendations on mechanical engineering programs, including the curriculum, faculty, and reward structure. The mechanical engineering program at the University of Minnesota Duluth is analyzed as a specific example, and a plan for implementing the *Vision 2030* recommendations is presented along with a discussion of potential difficulties including limited resource availability and accreditation issues.

Introduction

The American Society of Mechanical Engineers (ASME)[1] is the lead society which provides an interface between employers who hire mechanical engineers and academic institutions that produce them. Each year ASME sponsors the International Mechanical Engineering Education Conference to which industry representatives, mechanical engineering department heads, and engineering deans are invited. This paper is based primarily on information gathered during and after the 2011 Mechanical Engineering Education Conference.

The primary goal of the conference was to review, discuss, and revise a draft of the document *Vision 2030: Creating the Future of Mechanical Engineering Education*[2]. The document is the result of a multi-year effort to define the future of mechanical engineering education. The society surveyed over 1000 employers of mechanical engineers and involved many industry representatives in this effort to determine what important skills a mechanical engineer will need in the year 2030. The recommendations of *Vision 2030* include significant, broad changes to mechanical engineering education at the undergraduate and graduate levels that the ASME feels are necessary if future ME graduates are to meet the needs of industry and society.

Academia, unfortunately, is in a poor position to implement these recommendations. The demand for BSME programs has grown significantly over the past five years, while universities have experienced budget cuts and restrictions in resources over the same time period. This has

led to a situation where many BSME programs are understaffed and are barely able (or unable) to meet the demand for courses, much less to implement significant curricular changes.

Not ready to practice

The ASME recommendations focus on producing engineers who are ready to practice engineering in the current global environment. Many employers of mechanical engineers report having developed training programs, some as long as two years after graduation, to prepare new graduate engineers to effectively practice engineering within their organizations[3]. Industry representatives at the conference repeatedly stated that BSME programs should produce "engineers who are ready to engineer.[3]" As shown in Figure 1, the vast majority of mechanical engineering graduates (including those with masters degrees) go into practice, so it follows that the educational system should emphasize the preparation of graduates for engineering practice. Some of the weaknesses observed by industry representatives in recent mechanical engineering graduates are stated below.

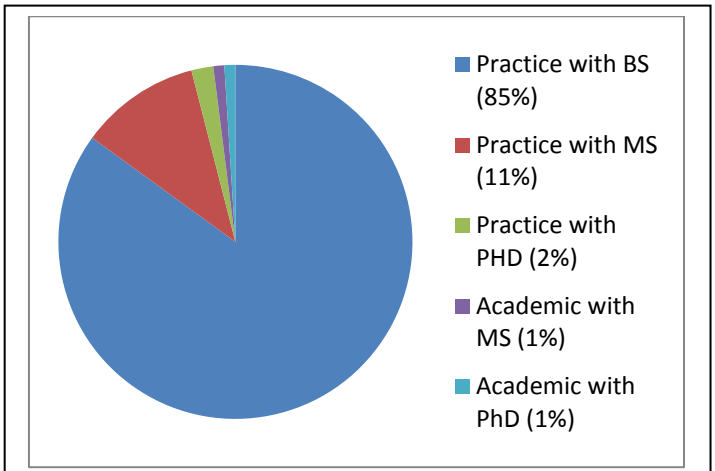

Figure 1. What do U.S. BSME Graduates do[4]?

Observations from industry[2]:

- Graduates do not reflect the current and growing diversity in the general population
- Engineering graduates lack practical, hands on experience
- Graduates are not able to formulate and solve complex, multidisciplinary, system-level real world problems.
- Graduates are not prepared to provide leadership and drive innovation at the level necessary to maintain the competitive position of the United States in the world.
- Graduates lack the professional skills (project management, business practices, communication ability, and multicultural awareness) to be effective engineers.
- Graduates do not fully appreciate the impact of engineering decisions on environmental and/or economic sustainability.

The academic perspective

Mechanical engineering educators were also heavily involved in the information-gathering process used by the Vision 2030 Task Force. The task force assembled the following statements on the weaknesses of current mechanical engineering programs based on the information gathered from this group.

Observations from academia[2]:

- The current mechanical engineering curriculum is not successfully attracting and retaining women or minorities.
- New graduates forget much of their technical education shortly after graduation, and use little of it during their professional careers.
- Many faculty members have less than five years practical engineering experience.
- Engineering faculty members are often very narrowly focused on their areas of specialization and tend to emphasize technical depth in their courses.
- Most BSME programs appear to be preparing students for graduate school and research-oriented careers rather than engineering practice, and this is out of proportion to the actual career paths chosen by graduates.
- The reward structure in academia heavily favors research-oriented faculty over practice-oriented faculty.

Vision 2030 Recommendations

Based on the information gathered over a two-year period from industry, academia, practitioners, and other stakeholders in the mechanical engineering profession, the Vision 2030 Task Force formulated the following recommendations for mechanical engineering academic programs.

ASME Vision 2030 recommendations for undergraduate degree programs[2]:

1. Should contain the same number of semester credits (120-128) as current degrees
2. Engineering fundamentals must be retained
3. A learner-driven degree with considerable curricular flexibility
    a. Pre-defined tracks (design, manufacturing, research, etc.)
    b. Many electives to allow students to "pursue their passion"
4. More practical content
    a. More hands-on experiences (how things work, how they are made)
    b. More design content, preferably distributed throughout the curriculum (a design spine)
    c. Emphasis on formulating and solving practical (big picture, multidisciplinary, systems level) engineering problems
5. Less technical content and more professional skills
    a. Innovation and creativity
    b. Communication
    c. Leadership
    d. Ethics
    e. Sustainability
    f. Business and economics

ASME recommendations for graduate degree programs[2]:

1. A stand-alone professional masters degree focused on providing more technical depth for practicing engineers (M. Eng.)
2. A Master of Science/Ph.D. track for research emphasis

Analysis

The recommendations for changes to mechanical engineering education are certainly worthy and are clearly based on the needs of industry. Each recommendation, however, presents some difficulty in implementation, especially in these times of shrinking budgets and severely limited resources.

The implementation challenges facing each recommendation for undergraduate programs are discussed below.

1. Should contain the same number of semester credits (120-128) as current degrees

   This simply means that for everything that is added, something must be taken away. This is an age-old problem faced by mechanical engineering programs which were first reduced from five years to four, and then asked to include additional content as the field of mechanical engineering continued to evolve. New materials, techniques, and analysis tools are added each year to an already crowded curriculum. To implement the recommended changes within the 128 credit limit would be very challenging, especially in the face of accreditation constraints.

2. Engineering fundamentals must be retained

   What is the definition of "engineering fundamentals?" Any mechanical engineering faculty will have difficulty making the distinction between fundamental and non-fundamental courses, with definitions of engineering fundamentals ranging from basic math and science courses to third-year courses in fluid mechanics and thermodynamics. More guidance is needed here. Does this mean graduates must be able to pass the current FE exam?

3. A learner-driven degree with considerable curricular flexibility

   Industry seems to have a vision of college students as passionately pursuing their goal of gathering as much knowledge as possible in their area of interest. Although this is accurate in some cases, most college students are undecided as to what they want to study, and are rather short-sighted. Many students are likely to take the easiest or most convenient route through a degree program rather than "pursuing their passion" for mechanical engineering. Leaving too much choice up to the student is dangerous. Well-designed, coherent tracks seem to be a better option than just a large basket of elective courses.

4. More practical content

   Providing practical hands-on experiences, active discovery-based learning, and realistic problem-solving and design experiences are admirable goals, but very resource intensive. Such activities require small class sizes and increased numbers and skills in the faculty. They also require a great deal of space and equipment to be realistic. Many BSME

programs have reduced their hands-on experiences, laboratories, and design options simply to save resources.

5. Less technical content and more professional skills

   Many BSME program faculties lack the talent or resources to teach topics outside of the core of mechanical engineering, like multi-disciplinary approaches to problem solving, innovation, communication skills, and professional skills. Removing technical content may also threaten program accreditation.

The implementation challenges facing the recommendations for graduate programs are discussed below.

1. A stand-alone professional masters degree focused on providing more technical depth for practicing engineers (M. Eng.)

   This is offered by some universities, but it usually amounts to a "coursework only" version of an M.S. degree. Professional Masters students often select courses from the same pool as M.S. students, and those courses are taught by faculty members with a strong research emphasis, not a practice orientation.

2. A Master of Science/Ph.D. track for research emphasis

   This track seems to be acceptable as it is, and that is no surprise since the vast majority of mechanical engineering educators (the "content providers") followed this same track.

The situation at the University of Minnesota Duluth

As is the case with many ME programs, the Department of Mechanical and Industrial Engineering (MIE) at the University of Minnesota Duluth (UMD) has been operating in an environment where the number of students is growing and the resources (space, equipment funding, faculty, and staffing levels) are staying the same or shrinking. Despite this, the department is better equipped than most to implement the changes recommended by *Vision 2030*.

The department has significant laboratory space and equipment to support hands-on activities, and the BSME program at UMD lists hands-on orientation as one of its strengths. Many students have cited this strength as their reason for choosing UMD. Laboratories must be run by faculty and maintained by staff members, however, and the limited resources experienced in recent years have forced the department to limit the number of laboratory course offerings. Laboratories that used to be taught separately have been combined to reduce the demand on faculty, and this has resulted in a reduction in the number of lab activities for students.

The department has also been very pro-active in providing students with real-world engineering experiences. Our senior design capstone course continues to execute projects with many client companies, and those companies have hired many of our graduates. Many students also take advantage of coop and internship opportunities which have grown in recent years. The reward system at UMD, however, heavily favors research-oriented faculty over practice oriented faculty,

and the department needs more practice oriented faculty if we are to continue to provide real-world, practice oriented engineering education. Other universities have implemented a 'Professor of Practice" title in order to address this situation[5].

The MIE department is also better equipped to deliver education in professional skills than most other mechanical engineering departments. Because the department faculty also supports degree programs in Industrial Engineering, Environmental Health and Safety, and Engineering Management, they have the skills necessary to deliver this content. The department recently proposed, with the Department of Civil Engineering, to offer an undergraduate minor in Engineering Management with a strong emphasis on engineering practice and professional skills. This seems likely to offer our students exactly what industry is looking for in engineering graduates.

When it comes to graduate education the department has offered a M.S. degree in Engineering Management and a Master of Environmental Health and Safety for over ten years, and now supports the M. Eng. degree offered by the Swenson College of Science and Engineering. All of these degree programs offer significant practice-oriented content, and additional technical depth, to engineering graduate students. These offerings also seem to be directly in line with the needs of industry.

Conclusions and recommendations

The recommendations put forth by the American Society of Mechanical Engineers in *Vision 2030* are worthy goals for mechanical engineering programs to pursue. Although the current draft form of the document needs some further definition and explanation, it clearly reflects the expected needs of industry over the next 20 years. Although the MIE department at UMD is better equipped than many ME departments to address these recommendations, meeting these goals by 2030 will require a significant increase in the resources available to the department. It will also require the department to emphasize the practice of engineering side-by-side with engineering research. To this end it is recommended that UMD create a Professor of Practice track for practice-oriented faculty members similar to the tenure track now available to research-oriented faculty members.

References

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