THE "5XME" WORKSHOP: TRANSFORMING MECHANICAL ENGINEERING EDUCATION AND RESEARCH IN THE USA

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The launch of the first artificial satellite, Sputnik, by the USSR in 1957 precipitated a transformative change in engineering education in the USA, towards a science-based engineering curriculum focused on fundamentals. For example, mechanical engineering education emphasized thermodynamics, heat transfer, fluid mechanics, solid mechanics and dynamics. Topics from mechanical engineering practice, such as internal combustion engines, heat exchangers, automotive body structures and machine tools, became viewed as applications of those fundamentals. This emphasis on fundamentals empowered engineering students, and enabled graduates to apply their knowledge and skills in a variety of different industries, and in emerging new technologies (e.g., aerospace, nuclear, computer, biomedical). However, this same emphasis on fundamentals has led to a weak link to engineering practice, and a lack of emphasis on industrial innovation and commercialization of technology.

Globalization, with the open flow of information, goods and people all over the world, brings significant benefits to all. However, it also creates challenges for the nation. In engineering education many countries now emulate the very successful USA engineering schools and their science-based curricula, and are making investments that produce an order of magnitude more engineers, and of comparable quality. Global companies employ such world-class engineering talent, often at 20% of the cost in the USA, and are moving manufacturing, design and even research activities to such locations. Furthermore, the national investment in mechanical engineering research, which has fueled the economy for decades with breakthrough technologies (e.g., CAD systems, MRI machines, non-destructive evaluation methods), is also being emulated by other nations around the world, which are recognizing the importance of engineering for economic prosperity, and are making the societal investments in engineering research and education. However, given current societal values, the USA is unlikely to significantly increase taxes for further public support of engineering education and research; in fact such public support has been eroding over the past 50 years.

We now face a national crisis more dramatic than the launching of Sputnik in 1957, and one that will require a creative and transformative response in terms of engineering education. The economy and prosperity of the nation will depend on our ability to respond effectively to such a changing environment, especially in core engineering disciplines like mechanical engineering. Mechanical engineering, which is often viewed as a mature discipline, is in fact rapidly evolving to encompass emerging areas such as mechatronics, MEMS, biotechnology, medical devices, cognitive engineering and nanotechnology. Furthermore, it retains a strong focus on design and manufacturing and remains one of the largest engineering disciplines in terms of undergraduate degrees and enrollments. *The challenge for engineering schools in the USA is how to educate a mechanical engineer that provides five times the value added when compared to the global competition, i.e., the "5XME"*.

Mechanical engineering education and research in the USA will need to link more closely with engineering practice and the commercial world to generate the necessary market pull

and resources for such a transformation. However, the current emphasis on engineering fundamentals cannot be sacrificed. To achieve the "5XME," mechanical engineering education must be transformed to embrace both fundamentals and practice; both the procedural knowledge of the problem-solving engineer as well as the declarative knowledge of the applied scientist. A similar transformation occurred in the automotive industry when some companies realized that they could beat the competition by producing vehicles that were *both* high in quality and low in cost. Also analogous is the transformation in medicine that occurred with the Flexner report in 1910, which led to a medical education based upon both scientific and clinical training.

The transformation needed in mechanical engineering education must embrace societal priorities, and become an exciting and attractive leadership opportunity for a diverse pool of talent from all segments of our society. Such a transformation will require a new infrastructure, and new methods of educational delivery, that develop the specific abilities of diverse students, to achieve the attributes that graduates must possess, e.g.:

1. Broad grounding in fundamentals
2. Flexibility and agility
3. Innovation and creativity to benefit society
4. Global focus
5. Teamwork and leadership
6. Communication skills

In education: Engineers must be broadly educated, not simply to solve problems others have set for them, but to identify problems and issues and to provide the technological leadership needed to benefit society. We must fully develop the potential and all the skills of our students to develop the new renaissance engineer, and bring the successful research and project focus of graduate education to undergraduate students in engineering.

In research: Engineers must practice concurrent discovery and innovation to fuel the economy, and benefit society, in a time of accelerating technological change. Emerging areas, such as macro systems (e.g., innovation, energy, environment, enterprises, service industries, health care, complex systems), micro/nano systems, bioengineering, information technology and cognitive engineering present new opportunities.

Similar to the change that occurred in engineering, to become a science-based discipline, after the launch of Sputnik in 1957, we are now looking for another transformative change to engineering education; this time in response to the global competition, and specifically to the fact that a science-based engineering education has become a commodity available to students all across the world, including low-wage markets. We urgently need to identify the attributes that the mechanical engineering graduate in the USA must posses to compete successfully in a global marketplace, where global companies hire engineering talent and establish engineering services, anywhere in the world. We need to identify the mechanisms (e.g., courses, curricula, internships, projects, engineering clinics) by which those students will acquire such attributes. We also need to develop a strategy, tactics and resources to move ahead with such a transformation on a national scale.

The National Science Foundation is sponsoring a workshop, to be held during May 10-11, 2007, to discuss these important and urgent issues, and to initiate the process of transformation (see http://www.umich.edu/~ulsoy/5XME.htm).

Selected References

Akay, A. (ed.), 2002, *New Directions in Mechanical Engineering*, Report from an NSF Sponsored Workshop Organized by the Big-Ten-Plus Mechanical Engineering Department Heads, Clearwater Beach, Florida, January 25-27, 2002.

Akay, A., "The renaissance engineer: educating engineers in a post-9/11 world," *European Journal of Engineering Education*, Vol. 28, No. 2, June 2003, pp 145–150.

Augustine, N.R. (ed.), *Rising Above the Gathering Storm*, Report of the National Academies, 2006.

Boyer Commission, *Reinventing Undergraduate Education*, Carnegie Foundation, 1998 and 2001.

Bush, G.W., *American Competitiveness Initiative (ACI)*, State of the Union Address, 2006. http://www.whitehouse.gov/news/releases/2006/01/20060131-5.html

Clough, G.W. (ed.), *Educating the Engineer of 2020: Adapting Engineering Education to the New Century*, National Academy of Engineering, 2005.

Collins, J. and J. Porras, *Built to Last: Successful Habits of Visionary Companies*, New York, Harper Business, 1994.

Colvin, G., "The Imagination Economy," *Fortune*, July 5, 2006.

Duderstadt, J.J. (ed.), *Engineering Research and America's Future: Meeting the Challenges of a Global Economy*, National Academy of Engineering, 2005.

Flexner, A., "Medical Education in the United States and Canada," 1910.

Friedman, Thomas L., 2005, *The World is Flat*, Farrar, Straus and Giroux, New York.

Geppert, L., "Educating the renaissance engineer," *IEEE Spectrum*, Sep 1995 Vol. 32, No. 9.

Hudson Institute, *Mechanical Engineering in the 21st Century: Trends Impacting the Profession*, ASME International, September 1999.

Laity, W., and the ASME Body of Knowledge Task Force, "A Vision for the Future of Mechanical Engineering Education," ASME Council on Education, November 2004.

Mote, C.D., Jr., "Lower Expectations for Higher Education?" *Washington Post*, Sunday, June 20, 2004, page B05.

Ulsoy, A.G., "A 21st Century Engineering Education for Leading Concurrent Discovery and Innovation," *CIRP General Assembly*, Antalya, Turkey, Aug. 2005.

Winer, W. "Benchmarking the Research Competitiveness of the US in Mechanical Engineering," National Research Council, 2006 (currently underway).

Tentative Timeline for The 5XME Workshop

5/06 Initial discussions by Adnan Akay and Galip Ulsoy.

7/06 Planning meeting held at NSF by the Planning Committee (i.e., Mary Good, Marshall Jones, Lee Matsch, Dan Mote, Galip Ulsoy – Chair) and Adnan Akay.

8/06 Input provided to Galip Ulsoy by Planning Committee Members to draft a White Paper. Workshop proposal submitted to Eduardo Misawa at NSF by Galip Ulsoy.

9/06 Workshop proposal funded by NSF. Draft White Paper and Timeline circulated to Workshop Planning Committee for further review and comment.

10/06 White Paper finalized.

11/06 Galip Ulsoy, with Eduardo Misawa and Adnan Akay at NSF, finalized the 2007 Workshop dates, location and list of potential invitees. Galip Ulsoy contacted Tom Perry at ASME to coordinate with the ASME Mechanical Engineering Education Conference (MEEC) in spring 2008 to disseminate results of the 2007 Workshop to a broader audience.

2/07 Galip Ulsoy and NSF finalized 2007 Workshop logistics, and Galip Ulsoy is to set up The 5XME Workshop web site, and send invitations, with tentative agenda and White Paper, to list of invitees.

5/07 Two day workshop to be held at NSF, with approximately 20-25 invited participants, plus NSF and other goverment personnel, for a total of about 30 attendees. This will be held May 10-11, 2007.

5/07 After the workshop, Galip Ulsoy to prepare a draft report for review and comment by Planning Committee members and NSF.

7/07 Based upon feedback on the draft, Galip Ulsoy will finalize the report, and disseminate via e-mail and Workshop web site.

8/07 Galip Ulsoy will prepare a high-quality printed “brochure” version of the report, with only Executive Summary and Recommendations, and reference to the web site where the full report can be downloaded as a PDF file. This brochure will be disseminated at major national venues (e.g., NSF, ASME IMECE, ASME Education Conference, ASEE Conference).

9/07 Galip Ulsoy will work with Tom Perry at ASME to arrange the Session/Symposium at the ASME Mechanical Engineering Education Conference (MEEC) in 2008.

3/08 Session/Symposium at the 2008 ASME MEEC, with special panel organized to summarize workshop report, and discuss recommendations with the ME Department Heads and other attendees.