Proceedings of COBEM 2009
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20th International Congress of Mechanical Engineering
November 15-20, 2009, Gramado, RS, Brazil

The Cloudy Crystal Ball and Engineering Education

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Abstract. *This paper and its accompanying presentation describe the author's experiences and opinions about the future of engineering education at both the undergraduate and graduate levels. Observations are presented on the factors affecting mechanical engineering education, and potential near and far-term influences are discussed. The need for flexibility and the effect of changing global conditions on planning for effective engineering programs are proposed, along with the observation that no common curriculum will be approriate; rather, each each college should base its program on its own perceived mission and culture.*

***Keywords**: engineering education, engineering future , global effects on education*

1. INTRODUCTION

It is more than a half-century since I obtained my engineering degrees. When I entered college, I grew proficient at using a slide rule; word processing was by use of a typewriter (if you had one); reproduction was by carbon paper or mimeograph; jet aircraft were rare; all telephones were land lines with a rotary dial; TV was black and white with a lot of "snow"; the single computer available for research at my university had 15k of active memory, and had punch card input and output. Was I smart enough then to foresee laptops, the internet, common international jet travel, the cell phone, high definition color TV, and terabyte massively parallel computers? Definitely not!

I don't think I am any smarter now, or more able to foresee 50 years into the future than I was fifty years ago. So any forecasting of the future of engineering education will have large error bars, and one thing that we can be sure of is that there will be many significant changes that we cannot foresee, and that flexibility will be necessary in any curricula or programs that we initiate.

Many serious studies have been made of the future of engineering education, and three recent ones have been done by the American Society of Mechanical Engineering, the US National Academy of Engineering, and the US National Research Council. References are at the end of the paper.

2. THE SPECIAL FEATURES OF MECHANICAL ENGINEERING EDUCATION

Mechanical engineering is the broadest of the engineering disciplines. It is easy to bring up a picture or icon that describes the other traditional engineering areas: Aerospace (aircraft, spacecraft); Civil (bridges, highways, buildings); Chemical/Petroleum (refineries, chemical plants); Electrical (microchips, computers, power plants); nuclear (reactors). What comes to mind when Mechanical Engineering is mentioned? I think different things to different people, and there is no single icon. Therein lies a challenge to defining what should be in the educational recipe for a Mechanical Engineer. The discipline is so broad that no single university can really cover it effectively, and it is to be expected that every university will have different emphases in their program.

The following includes some personal observations about engineering education.

First, there are significant differences in the aims and needs of an engineering educational curriculum that come about because of differing cultural, national, and institutional aims. Emphasis may differ on the relative importance of strong fundamentals vs. innovation and problem solving; individual excellence vs. team interactions; preparation for academic vs. industrial careers; research vs. application; solution of "traditional" vs. open-ended problems; and others. The best curriculum for one institution or country may be very different from another, depending on the perceived relative importance of these factors. Faculty love to argue over all of these issues!

Second, there are changes that are occurring rapidly in the tools that students bring to the classroom, and the impact of these changes on the learning process is not yet fully resolved. Most students come to us with great facility in using the internet for information gathering. Also, their competence in using contemporary math packages opens up vast opportunities for comprehensive problem solving, and investigating the effects on a solution of varying parameters. Student reports and homework can be prepared in amazingly professional formats, and electronically submitted. There are, however, negative aspects to this increased information access and computer capability. Based on my observation, many students now show considerably less enthusiasm for using traditional textbooks, and often do not put in the effort to understand material in depth. They are not willing to spend the time to fully understand detailed derivations or arguments; after all, it's all on the net! They seem to think that anything not in a computer searchable database must be unimportant, and the vast technical literature produced prior to about 1985 thus becomes lost to them. The importance of peer review in vetting information is not part of their mind set, and they often accept information on the net without question. We have a serious responsibility to address these issues for our students.

Third, as professors, we have many new tools available to enhance the learning process. Computer-based and visual resources, the availability of powerful math packages (Matlab, Mathcad, Maple, etc.) to extend the range of homework and test problems, the use of "patched" texts (parts or chapters taken from various sources to make a custom text for a course), access to computerized tables (making the teaching of double interpolation of values in the steam tables no longer necessary!); all of these present opportunities for enhancing learning. However, the audio/video/computer technologies underlying these tools come and go with alarmingly short lives. Videotapes are nearly gone, and the CD shows signs of becoming passe'. Old programs written and stored on early-generation disks may not be retrievable now, and if you have put a lot of time into producing classroom tapes and transparencies, it can be discouraging to see that effort become unusable. Archiving materials and updating to the new formats and technologies for providing them becomes a time-consuming part of our professional lives.

3. POSSIBLE FEATURES OF ME CURRICULA

Given all of these changes, is there some common ground to help in designing future curricula in Mechanical Engineering? Considering the cautions about differing cultural, national and institutional viewpoints, aims, and needs, and the uncertainties about technological changes that we face, here are some thoughts on the general material we should we teach.

First, consider undergraduate programs. Most undergraduate students still go to industrial/entrepreneurial careers. A contemporary undergraduate therefore needs to have a broad engineering education in traditional areas of interest to industry, along with a basis for potential graduate studies. Under pressure from industry, we have often incorporated material on team approaches to problem solving, the use of open-ended problem solving, and capstone design courses that incorporate teaming on a broad engineering problem. New courses and structures may be needed to address emerging areas such as bioengineering and nanoscale phenomena. However, how much demand do we see for undergraduate students in these areas? How do we continually adjust to change in these demands? The undergraduate program should include studies in societal integration appropriate to the mission of the institution. However, as we add new engineering material, how much room is left for such broadening of engineering perspectives (ethics; the international scope of engineering; business/finance.; social studies and the arts; etc.) We complain about the necessity of balancing the need for traditional hard-core engineering material with the newer needs. Traditionally, the undergraduate curriculum *structure* tends to change slowly, although individual course *content* may change rapidly. The good news is that we have long experience in handling the undergraduate curriculum; changes in the structure tend to be incremental for good reason.

In contrast to an undergraduate program, it is much harder to define the attributes of a graduate curriculum and its future. There are always very rapid changes in research and educational emphasis at the graduate level. Consider the emergence of biotech, micro-nano, computation, inverse methods, unconventional energy, the ability to acquire and visualize full-field data (TCs vs IR camera; pitot tubes vs. laser fluorescence) and others. These require new technical backgrounds for our students, which pushes us toward stronger interdisciplinary interactions. In the face of these rapid changes, should we establish new graduate degree programs or fit these new areas and courses within the existing graduate structure? Care is needed in making these decisions; in the US in the 1970's, we established departments, degrees, and programs in solar and renewable energy, robotics, and advanced manufacturing. These were seen as very important at the time. As emphasis, priorities, and funding changed, most have now disappeared or been absorbed into established degrees such as ME. Five year combined BS/MS programs were tried as a way to incorporate more material into the traditional undergraduate degree and also open a path to graduate studies; again, most of the five-year programs have disappeared for various reasons. On the other hand, bioengineering departments have been established at many universities, and so far appear viable.

Have I outlined the future of engineering education? Only to the extent that I'm sure it will be characterized by continual revision and it will have a local flavor to embody local needs and aims. Our societies continue to impose rapid, unforeseeable, and surprising changes; therefore, no matter what we do, the material we provide won't last throughout a student's career, and maybe it won't be useful for very long at all. However, I hope that we will have the foresight and ability to provide our students with the education, tools and capability of coping with the changes and challenges they will face.

4. REFERENCES

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