EDITORIAL

Issues for Engineering Educators

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Most readers of *Sound and Vibration* would not anticipate an editorial on engineering education from someone not at a university. But regardless of the fact that I do not work at a University, I do consider myself an educator. In fact, I believe that every experienced engineer has the duty to educate, train and mentor young people just entering the profession.

My comments here are based on more than 20 years of experience as a mentor for undergraduate and graduate school interns at Los Alamos National Laboratory (LANL), my experience in developing and evolving the Los Alamos Dynamics Summer School over the last nine years, my experience leading a collaborative education and research initiative between LANL and the University of California San Diego's Jacobs School of Engineering, and countless formal and informal interactions with university students, faculty and administrators over the last 25 years. I firmly believe that editorials should "hang out the dirty laundry" and promote discussion of issues that might make some uncomfortable. This editorial will be no exception and, as such, I must state that the opinions expressed herein are mine and do not reflect those of my employer or the universities with which I interact.

Before discussing issues related to engineering education, I would first like to suggest some interesting reading on the topic. I think anyone concerned with engineering and science education should read the recent National Academy of Science report entitled "Rising Above the Gathering Storm (RAGS)," which addresses the issue of economic competitiveness and the role that technology plays in maintaining our county's ability to compete in an ever-increasing global economy. This report is available from the National Academy Press, http://www.nap.edu/catalog/11463.html, and a 16-page summary can be downloaded free of charge. Readers should also familiarize themselves with the America Competes Act (ACA), http://www.whitehouse.gov/news/releases/2007/08/20070809-6.html, which is the legislation to enact the recommendations from the RAGS report. If an appropriation is made, this legislation has the potential to profoundly impact university education and research over the next 10 years.

The ACA has many provisions aimed toward increasing the number of Ph.D.-level scientists and engineers in the U.S. However, from my perspective there is not one provision that will directly impact engineering and science education curricula at the university level. The assumption is that if you have more Ph.D. scientists and engineers, then somehow education and curricula will evolve and improve just due to the inertia associated with these increases.

Nothing could be further from the truth. I feel that it is currently detrimental to the career of an engineering faculty member, particularly young faculty members seeking tenure, at schools that fancy themselves as "research institutes," to spend any creative energy on education and new curriculum development. Administrators (department chairs and deans) simply do not reward such activities, because they do not add to the bottom line of research funding that is the current basis of merit. Additionally, unlike research grants, educational activities cannot be taxed to produce the revenues that many engineering departments need to balance their budget. In addition, achievements in education are much harder to quantify than achievements in research, which are conveniently measured through research dollars and publications.

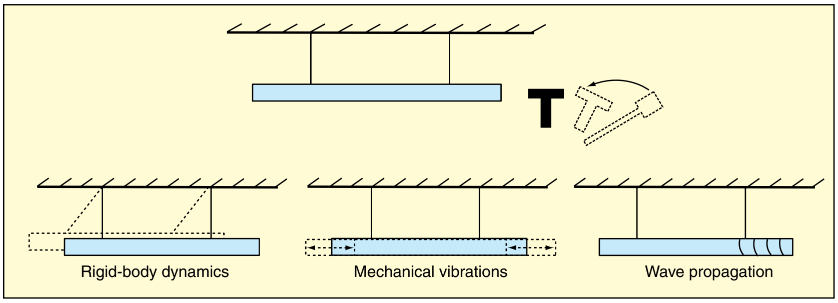
This lack of emphasis on education will continue until some real leaders emerge in the administrative ranks at our research institutes who are willing to change the current business models that are prevalent throughout our higher education system. Such change will not occur without the buy-in from all levels, including the chancellors, boards of regents, faculty governing bodies, and in the case of public universities, state legislators. This impedes achieving consensus even more.

In this regard, I do not believe that the recommendations in the RAGS report will accomplish what its authors set out to achieve. Improved economic competitiveness based on innovation and creative thinking will not be realized through an increased number of people with advanced degrees who are educated in a system with outdated curricula. Curricula and education must evolve along with technology. I think that this oversight in RAGS and ACA arises because the authors of the report, although very accomplished researchers and technology administrators, are most likely not involved with education innovation and curriculum development, particularly at the undergraduate level.

I will share some antidotes related to this lack of leadership in the education ranks. Not too long ago I was asked to give a seminar at a smaller state university that I will leave unnamed. My faculty hosts told me about how the university president laid down the law to them that they were going to become a premier research university. These same faculty members, who are relatively low paid by university standards, said that they had to teach 2-3 classes per semester and that they didn't receive ABET accreditation during their last review because the review board felt that they didn't have adequate labs for their undergraduate classes. From my perspective someone at this institution was missing the big picture. This business model is doomed to failure. If any faculty member can be a successful researcher in such an environment, they will be hired away by another school with more resources.

At another university, which is considered by many to have the reputation as one of the premier engineering schools in the country, a faculty member recently told me their "dean was all for being a leader in education innovation so long as they were not the first to implement the changes." Although the deans and department chairs are often considered the "leaders" at the universities, I think we tend to get the term "leader" and "risk-adverse administrator" confused.

When I reflect on my undergraduate engineering education, I see the results of this imbalance in priorities between research and education. The faculty I had for dynamics classes, including rigid body dynamics, vibrations and a class that taught aspects of wave propagation never provided the "big picture" of how these subjects are related. In my opinion, every dynamics class should start out with the example shown in the figure, where a bar suspended from wires is impacted by a hammer. The professor needs to address the fact that this problem can be analyzed as one of rigid-body dynamics, modal vibration or wave propagation depending on what question the engineer is trying to answer. Fundamentally, the difference is the length and time scales on which we are trying to model or measure the dynamic response. Then the professor needs to explain how the particular course material relates to this problem and what the models explore-



din the class can and cannot do. Without such a "big picture" overview the students get in a mode of viewing each class as a discrete topic as opposed to the interrelated topics that they truly are.

There is clearly a need for education innovation and curriculum innovation. Most universities in the U.S. have traditionally been very good at training the technical specialist, and this tradition must continue. However, I believe that we currently have a need for technologists who should be trained in a much more multidisciplinary manner. In particular, the technology leaders of the future will be required to integrate diverse technologies in an effort to continue our innovation and evolution. Currently, U.S. universities are generally not that well prepared for this emerging mission. Furthermore, this mission will have to be a balancing act between developing students with a broader technology base, while still allowing them to focus enough to complete a thesis or dissertation. I believe the sophomore curriculum that has been adopted by Rose-Hulman Institute of Technology is an excellent example of how the undergraduate curriculum can be modified to better train these future multidisciplinary technology leaders. I believe the graduate curriculum that our LANL/UCSD Engineering Institute is promoting in structural health monitoring, damage prognosis and validated simulations, which cuts across the entire Jacobs School of Engineering, is an example of one such multidisciplinary graduate education program. Such curriculum changes will occur more rapidly if government agencies and industry work interactively with universities to provide the motivation for education innovation, not just on research.

Finally, if one wants to explore real evolution in undergraduate curriculum, the very basis of our university education system must be called into question. Almost all undergraduate education is time based. By this I mean that students take a class and if you 'pass' with a 'C' you move on to the next class. These classes are taught at one pace, usually geared to the C+ to B- student. At the end of an undergraduate degree, it is not clear what the student has really learned.

I suggest that we consider performance-based education, where a student has to demonstrate clear proficiency in a class before the student can proceed to a subsequent course in the curriculum. Such an approach allows for the fact that students learn at different rates. This approach would not penalize a slower learner or someone who can absorb and understand the material in a much more rapid manner. I believe the student's knowledge when they actually receive a degree would be, on average, higher than that produced by our current system. However, such an approach would require faculty members to spend much more time on their courses to accommodate the students that learn at different rates. Also, the university could no longer give a student a definitive answer on how long it will take to graduate. Perhaps one could start with a modified version of this performance-based education just in the core engineering science course such as statics, dynamics, strength of materials, fluid mechanics and thermodynamics.

I'd like to end with a message to students. Having been involved with some of the brightest undergraduate engineering students in the U.S. over the last eight years in our dynamics summer schools, I have seen how much you emphasize the ranking of engineering graduate schools when choosing which you would like to attend. These rankings are flawed. Your experience in graduate school is going to be a function of your individual advisor, the research project you work on, and the mentoring you receive. These rankings will not give you information on these issues. Many aspects of these ranking are very subjective, and it is my opinion that these rankings hurt our higher education system, which you students are an integral part of, much more than they help it.

Your career will be off to a good start if you do well at any engineering graduate school and receive good mentoring from your advisor. Do your research to find out who these good mentors are by talking with their current and past graduate students as well as the other graduate students in the department who have chosen not to work with your prospective advisor. SV

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