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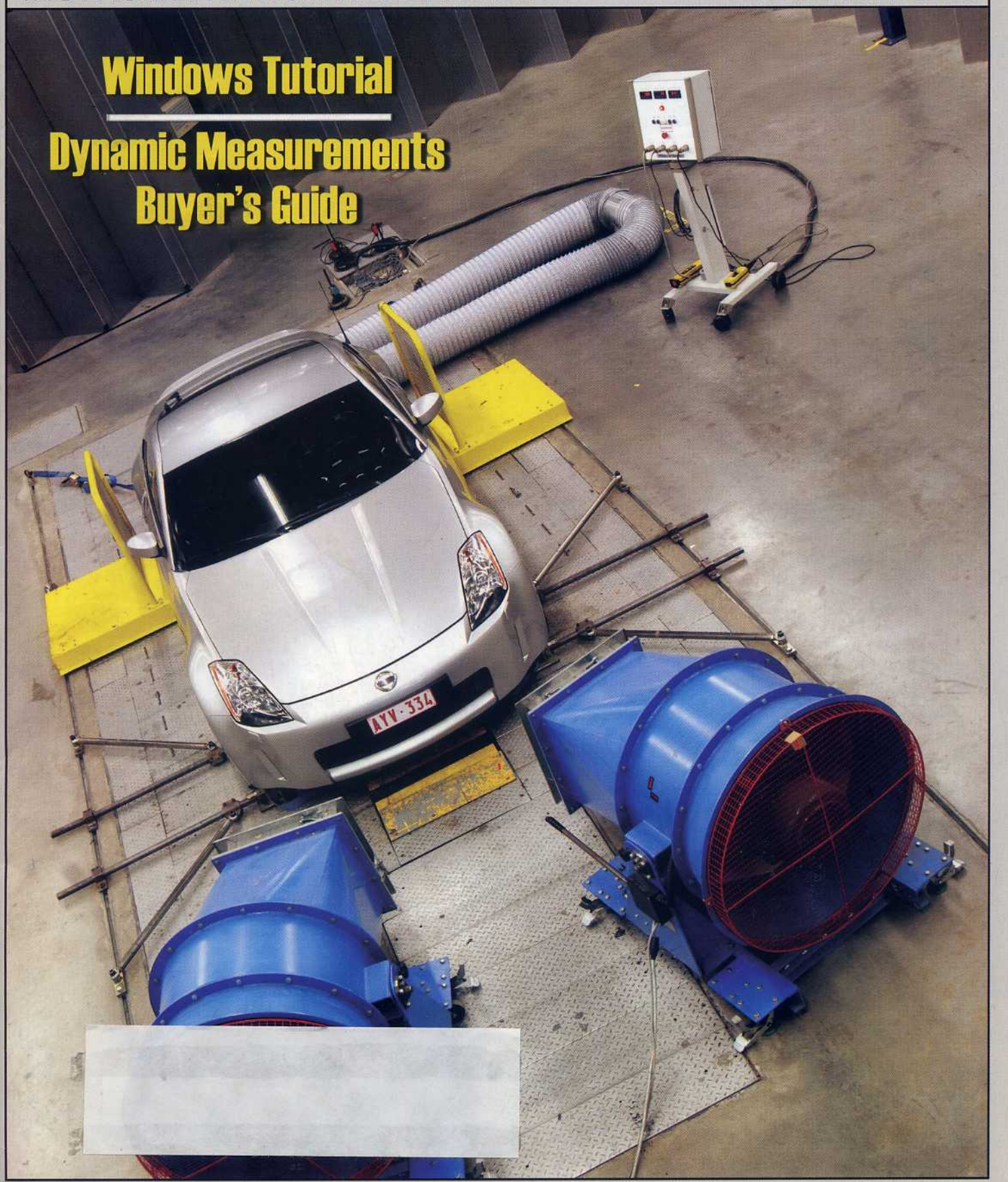

More on Engineering Education – A Renaissance in the Offing?

***Strether Smith**, Contributing Editor*

In my editorial "A Commentary on the State of Engineering Education," for the July 2004 issue of this magazine I was brave enough to publish a diatribe describing my myopic view of the state of "dirty-hands" engineering education. In that editorial, I expressed the opinion that 'practical' engineering had largely disappeared from the curriculum of most mechanical engineering schools (on the rash assumption that it had been there in the first place). The editorial included comments from an industry source that agreed with me and an opposing argument from a representative of academia that did not. The editorial requested feedback, and that is certainly what it produced:

- A rebuttal editorial (Oct '04) from Robert Bittle at TCU (Texas Christian University) describes the ABET (Accreditation Board for Engineering and Technology) and its effect on engineering schools with specific reference to the TCU program. The ABET is the recognized accreditor for college and university programs in applied science, computing, engineering and technology.
- Three rebuttal editorials from Peter Avitabile describe the program at the University of Massachusetts, Lowell, and discuss the trials and tribulations of engineering education in general (May, Jun & Jul '05.
- More than 30 messages from a wide variety of respondents.
- An invitation to discuss the matter as the keynote speaker at the Vibration Institute 2005 National Technical Training Symposium.

I will leave it to the reader to review the excellent editorials by Professors Bittle and Avitabile. They describe the programs that are available at their schools that are designed to answer the criticisms in my original rant. The following is a discussion of my discourse with a lot of folks that care and my updated view of the situation.

I have arbitrarily broken down the messages into three categories:

- Old engineering professionals – Codgers
- Younger engineering professionals – Youngsters
- Engineering school professors – Educators

The **Codgers** almost universally agreed with the premise of the original editorial. One particularly vehement response came from one author who requested anonymity:

*Hands-on courses have essentially disappeared or have become so watered down (with canned labs) that they are ineffective. It is almost impossible to hire a new graduate that has any ability to conduct a meaningful experiment. They don't know what questions experiments can answer, don't know how to define an appropriate experiment, don't know what diagnostics will be useful, don't know how to apply the diagnostics, don't know how to interpret the data, don't know how to do an error analysis to estimate error limits, don't know what instrumentation to use and what limitations are built in due to instrumentation choices and have no idea what conclusions to draw from the experiment. They can't do hand calculations to estimate results or to verify the order-of-magnitude answers from their computer programs. They do not have an appreciation for what **can and can't** be calculated and therefore cannot make appropriate comparisons between experiments and computer-generated numbers. Finally, they have no ability to write about the expected results of an experiment.*

Codgers that did not agree completely with me said that *most* schools do not produce dirty-hands engineers. Several discussed hiring practices that they thought separated the wheat from the chaff.

There was also a common theme that ran through the **Youngsters'** responses. All considered themselves to be dirty-hands types, but none gave much credit to their college education. The recurring theme was that their main practical experience came from 'playing' with cars and/or motorcycles and that their education reinforced that practical knowledge with theory and further examples. From Ed Milich came a typical response:

I personally spent many hours working on motorcycles and cars while in school, and my hands-on knowledge of motorcycle and automotive mechanics served me invaluably in my analytical education. Conversely, my classroom education deepened my understanding of practical mechanics such as tuning engines.

One can argue that any student's understanding of both hands-on and analytical engineering is limited only by their education, talents, and curiosity. In any case, I can unequivocally state that recent university-trained engineering graduates have had a tremendous opportunity to develop their practical dirty hands skills at the same time that they learned the fundamentals of analytical engineering. It is the responsibility of each engineer to make the most of these opportunities.

A critical factor is found in Milich's last sentence. Its converse is a philosophical problem that we all hear regularly. All of the youngsters agreed that their classmates who did not bring dirty hands to the table left equally clean.

In addition to the editorials, there were several responses from **Educators** that offer significant hope. Michel Louge from Cornell writes:

*When Dean Taylor, teamed up with A George to create M&AE 225 "Mechanical Synthesis" back in the mid 1990s, their objective was to **rejuvenate** the teaching of mechanical engineering with real-life design situations. In that course, students learn team dynamics, computer-aided design, planning, benchmarking, reverse engineering, rapid prototyping and yes – they also all learn to use lathes, milling machines and welding safely.*

Here we have what I think is a description of the critical change that is happening in engineering education. Recall that my original editorial was prompted by what I saw as a retreat from practical engineering instruction at Cornell in the 1960s. Louge's response indicates that the Cornell faculty came to the same conclusion 30 years later and decided to do something about it.

At about the same time, the program at TCU described in Robert Bittle's editorial and Pat Walter's contribution to my original piece was started. Other schools were experiencing the same renaissance during that period. The ABET program, discussed by Professor Bittle, also came on the scene about that time. My conclusion is that some colleges and universities have realized that there is a problem and have chosen to do something about it.

Of course, what to do is not obvious. There have been huge advances in technology since the 1960s, and subject matter must be adjusted accordingly. Joseph Prahl from the Case School of Engineering says:

There is always a concern over how much to shift the curriculum away from drafting, free-hand sketching and lettering, wood shop, model shop, foundry or machine shop to make room in four years for new industrially relevant developments, such as solid modeling, rapid prototyping, computer-aided design and manufacturing, not to mention new conceptual developments such as, micro-electro-mechanical systems, nanotechnology and modern numerical methods and codes such as MATLAB® *and* MATHEMATICA®.

The fact is, there are many things that used to occupy immense amounts of time in past engineering curricula that are no longer needed or appropriate. We do not have to spend inordinate amounts of time learning to use log and trig tables, practicing how to interpolate to get accurate answers. This does not mean that we should not understand logs and exponents fundamentally, but we do not require the application of the tables the way we used to. We can apply our time to more worthy pursuits. Students today do not need to know how to use a slide rule or a lettering set or mechanical drawing instrument. It simply is not necessary.

In my original editorial, I specifically lamented the passing of the foundry class at Cornell. I wrote "a good foundation in sand casting is a good start toward understanding the difference between a good and bad shock response spectrum." This may be true but is obviously a stretch. Some topics have to go to make room for new things.

There has been an obvious (and necessary) trend toward a more analytical curriculum in all schools. The computer, barely a concept when I was in college, has become our central tool, regardless of whether we are in analytical or experimental regimens. Fortunately, many schools have instituted, or held on to, practical mechanical programs of several types.

I was fortunate to visit TCU and have Pat Walter give me a quick tour of their facilities. I discussed their industry-sponsored program with him and several of the students. This program requires the senior class (28 students) to produce a product that is contracted by a requesting organization. That year's project, sponsored by PCB, was to design and build a calibration system to characterize accelerometers in the 0.05 to 5 Hz frequency range. No simple job, and certainly one that had not been done before. The task included negotiation of specifications with the customer, design, construction, proof of performance, cost accounting and control, documentation, and "sell-off" to the end user. All of the project responsibility fell on the shoulders of the participants. Participation in this program is required for graduation.

Many schools offer an alternative approach to dirty-hands experience. These optional "extracurricular" programs take advantage of competitions sponsored by a variety of industry and government organizations. Examples include "Formula SAE," the "Great Moonbuggy Race" and a variety of autonomous-vehicle programs such as the "DARPA Grand Challenge." These competitions provide real wrench-turning experience under high-stress (industry-emulating) conditions. These programs are terrific. The only problem is that they are optional. If we are hiring graduates, we should look for ones that have participated.

However, an issue that was disturbing to me arose in the DARPA Grand Challenge. Although it was an open competition, many of the teams were from academic institutions. In fact, the first three finishers were from schools. However, only one of these teams (that entered two cars that came in 2nd and 3rd) had significant student participation. It was obvious that their approach was to be a learning experience for the team members. Their school made the "honor role" that will be found at the end of this editorial. The winner did not.

There is a side issue that deserves comment. In the original editorial I asked whether mechanical engineering students are required to have run a lathe and milling machine. In this case, I mean a real manually controlled machine, not the CNC (computer numerical control) variety. Most of the schools that I contacted had these machines but, in many cases, the students are not allowed to operate them because of liability concerns. The machines were demonstrated and, of course, only good practices were displayed. The students did not have a chance to ruin a tool or a part because of impatience prompting too deep a cut. This is not an acceptable situation and these schools should either solve the liability problem or stop pretending that they are teaching dirty-hands principles.

So, finally we are to my bottom line. My conclusion is that there definitely are colleges and universities that do offer practical, hands-on, education programs. However, many do not. The challenge to those of us that hire graduates or want to help young people get an education in mechanical regimens is to find schools and programs that produce the type of graduate that we want.

Responses to my request for feedback produced the following short list of schools that offer a mix of high-quality academic and dirty-hands experience. These schools were recommended by graduates or demonstrated their capabilities by appropriate responses. In alphabetical order, they are:

- Carnegie Mellon
- Cornell
- Cal Poly
- Michigan State University
- Michigan Tech
- Texas Christian University (TCU)
- University of Massachusetts Lowell
- University of Missouri-Rolla

I am sure that there are many more schools that should qualify for this honored list. I'd like to publish another editorial in a year or so and would hope it includes a comprehensive list of schools that we should be contacting to hire their graduates or that we should be encouraging student engineers to attend. Please contact me if you would like to nominate others or have additional comments.

Thanks to all of you who responded to the original editorial. I hope that it was obvious that my long-term intention was to show my premise was wrong. Although the jury is still out on most engineering schools, the situation is better than I had thought. SV

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