EDITORIAL

And More Again on the State of Engineering Education, Part 2 of 3 – Improvement

***Peter Avitabile**, Contributing Editor*

In Part 1 of this editorial, I explained some of the approaches to teaching engineering students here at UMASS Lowell, and how they have been employed to instill a firm understanding of practical, real-world engineering problems. In Part 2, I will continue by explaining what I think still remains as an ongoing problem in education today and what needs to be done to remedy the situation.

So after reading Part 1, you may be thinking that the state of engineering eduction must be great. Wait . . . what's that you say? You haven't read Part 1 yet? "Go to jail! Go directly to jail. Do not pass Go! Do not collect $200." No get out of jail free card is available. You must read Part 1 before you proceed.

Of course you can do whatever you want and I can't make you read Part 1 of this editorial. So what does that mean? It means that I will take some points off of your grade to be received at the end of this editorial. It means that you may only get a B or if you only read part of this editorial then maybe you will get a BC. In any event, you will get some grade which is passing for the course and enters into your cumulative grade. At the end of this editorial series, you will have some overall grade. But what does that grade really mean? If you read this editorial in the library at MIT will there be an implied "I learned more" than had you read it in the UMASS Lowell library or the TCU library? And just because you answered the questions on the quiz correctly, does that imply that you really understood what I tried to convey? Of course not. You may have read the words but didn't really understand what I was trying to say. How many times have you been in a meeting while important items are discussed and some of the meeting participants are reading e-mail, doing other work, etc., and not really listening to the task at hand?

Well, welcome to a day in the classroom where students arrive late, wander in and out of the classroom, send text messages to their friends, surf the Web, read e-mail, etc. – *if* they even attend class at all. Then as they try to perform a particular assignment, they are not sure what to do since they have not devoted their time appropriately in class. It is a common problem at all universities. Students do not always come to the university for the same reasons – some think they like math and science, some know they want to be engineers but do not know what engineering is really all about, some are actually in school because their parents want them there, and even some students are there so that they can be covered under their family's health insurance program! You'd be surprised at the many reasons I have heard. How do you motivate ALL of these different personalities?

I would venture to say that all professors truly attempt to impart real knowledge to their students. But some of these students may not be ready mentally, spiritually or emotionally to partake in the educational process. When this is the case, it takes a bulldozer to get some of the simple concepts across to them in a meaningful way. The students that take the most away from their education are those who are truly devoted to learning. These students are a pleasure to have in class. They come prepared to learn by reading assignments ahead of time, doing additional homework problems, exploring and extending themselves by learning more than is asked or anticipated and taxing the instructor with difficult, probing questions. But these students are not the norm by any means.

One of the problems that I see is the mode with which material is delivered to the students. A curriculum is broken down into a series or sequence of required courses that is necessary to bring a student to a certain level of competency. A particular course consists of 10-15 weeks of lecture of material from a textbook where the material is very well organized and compartmentalized into modules of knowledge. Each chapter of the textbook is well organized with problems at the end of the chapter that are organized in the exact same sequence as the material is developed. And, of course, the students always ask what material is required for the next test so that they know exactly what to study to gain a grade that demonstrates command of the material. The unfortunate part is that as soon as the test is over or the course is completed, the students often just forget the material since they have no reason to retain the compartmentalized, modularized material. So why does this happen?

The answer is really very simple. There is no reason for the students to retain the information since it has no specific importance to them. Consider the analogy of a jigsaw puzzle. Each piece of the jigsaw puzzle has a very specific place relative to the entire puzzle. From the instructor's perspective, each individual piece has very significant importance to the big picture. There are hooks from each piece that go into other pieces of the picture. And each piece has places where hooks from other pieces need to be attached. The instructor clearly understands each piece and its importance since he clearly sees the entire picture. But let's face it – if I gave you one piece of a jigsaw puzzle or even three or four unrelated pieces, could you tell me what the big picture is or how the pieces fit into the puzzle? Of course not. So what happens is that the students get pieces of the puzzle in small doses with no real comprehension as to how or where all the pieces fit. It is most likely not until they have finished their entire education that some of the pieces of the puzzle make any sense at all. In order for the students to have a clearer picture as to the importance of each of the modules, there needs to be an interweaving of material across all of the STEM (science, technology, engineering, mathematics) courses throughout their entire educational experience.

Another very important consideration is the practical relevance of the problems that are routinely contained in each chapter of the text. Generally, the problems are very well posed and are fairly deterministic and the required information to solve that problem is probably as you guessed – right in that chapter of the text. Now let me remember . . . when I worked in industry all the problems I had to solve were exactly like the ones in the text, right? Of course not. Real-world problems require a deep understanding of all the material taught in the overall education.

I know that when I teach courses such as Vibrations, many projects require simple hand calculations coupled with simplistic finite element models to give more depth to the problem at hand. And I don't mean a big finite element model with 8 billion elements and every color in the spectrum to show the deformed shape. The models used are simplistic lower order models that provide additional insight into the problem. And there are no solid models allowed to find characteristics of CG, weight, mass moment of inertia either!!! Get out those text books on statics, dynamics, strength of materials, numerical methods, basic finite elements – and put together a simplistic model with 10 or 20 degrees of freedom using MATLAB®. No precanned FEM codes are allowed, either. You need to understand the basic material before you are allowed to use sophisticated tools!!! And you better be able to make a free body diagram correctly. The students grumble (and often curse), but the evil professor realizes that this is necessary in order to really comprehend the material well.

And as far as laboratory courses are concerned, I have a very specific approach. Many schools will provide well-behaved, deterministic laboratory data that produces very expected results. Such an approach can be beneficial for some laboratory exercises if the goal is to illustrate a theoretical concept presented in class. However, I feel that many laboratory experiences must have messy, contaminated, ugly data sets that must be interrogated to find the answer hiding in the dark. This is the way real life is – so the students must be exposed to this cruel world at some point in their lives, otherwise they depart from the laboratory course thinking that everything is a bed of roses. (And they had better have a properly documented logbook in the lab at all times.)

As far as I am concerned, the only way to truly understand material is to struggle trying to solve a real problem. And, *all* course material comes into play when working with real laboratory data. The students must struggle with concepts to solve realistic problems. The professor is really only a coach or mentor in the learning process; the student is the one who needs to drive the learning process. Remember that the only way you learned how to use a hammer or a drill was when you did it yourself. Watching dad do it really didn't impart deep understanding until you smashed your hand yourself.

What, then, needs to be done in order to improve the learning process? Material needs to be integrated across the entire curriculum (which is so much easier said than done). There has to be a requirement for students to understand all their material from previous courses. When students ask me what they need to know for a test, they never like my answer. I tell them, "Everything is required for the test." As one of my colleagues says, "You need to live this material everyday – not just for the test." The only way for this to happen is for the students to begin taking ownership of the material and taking charge of their learning. The traditional lecture format does not necessarily provide the right venue for full, deep learning. As one of the visual methods in teaching states, "After two weeks, people generally remember 10% of what they read, 20% of what they hear, 30% of what they see, 50% of what they hear and see, 70% of what they say, and 90% of what they say and do." So guess what . . . hands-on application oriented projects seem to fit the bill in order to impart deep understanding of this type of material. But this imposes a very serious faculty commitment of time and resources that many of us simply do not have! It is impossible to do this in every course for every module. Some blend between hands-on and traditional lecturing is likely the best way to achieve this goal. In short, we need to teach the students how to think and how to learn as a lifelong commitment they must follow. The engineering curriculum must embrace this philosophy to impart deep understanding of material that forms the foundation of engineering knowledge. In the last part of this editorial, I will continue on some additional issues that cause concern. (And remember, there may be a pop-quiz, so I expect that you remember all of this whether you see the relevance or not!) S/V

The author can be contacted at peter_avitabile@uml.edu. Part 3 will be presented in the July 2005 issue of *S&V.*