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Forbes magazine recently reported, for the second year in a row, that the hardest job to fill in the United States is that of an engineer. Apple Inc., the largest technology company in the world by market capitalization, announced (in an article in the *New York Times*) that it chose China over the United States for manufacturing the iPhone not so much to cut costs, but more so because of the ready availability of a large number of engineers, a situation not presently available in the United States. It is a well-publicized fact that our children in schools lag behind their counterparts in many industrialized countries in Europe and Asia. It is also true that our society in general views engineering as too science and math intensive, hence more difficult to comprehend and master. Educators in North America are well aware of this. Can anything be done to solve this problem?

As an instructor involved in electrical engineering education for 25 years, let me add my 2 cents on this subject. In every undergraduate class, I see a number of bright, motivated students. In fact, I will state that our best students can compete with the best students from any univer-

sity. And this is typically about 15% of the class population. It is the rest, which make up a large percentage, that are worrisome. The root of the problem is their study habits. Despite the fact that it is drilled in repeatedly by teachers and advisors that they must spend 3 hours studying outside of class for every hour spent in the classroom, they spend less than half this time, on average, over the entire curriculum. This is a number that was obtained through surveys of graduating seniors, year after year.

I am amazed at how many students go through the motions of attending classes without taking notes. When students take notes, they are writing it in their own words. Later (hopefully on the same day as the lecture) when they refer to their notes along with textbook reading, they will understand the subject better. I think that I speak for everyone when I say that the textbooks of today are so much better than those we had to study from, with lots of color illustrations and examples.

When I was a student, all that I was allowed to take into the examination hall were writing instruments and a calculator. I understand that this was the same universally. It is still the same in many Asian countries. I believe that although this is not always fair, it represents the best argument for creating a level playing field for everyone. What they have understood (or even memorized) by hard work is not easily forgotten and they have to possess good written communication and problem-solving skills to succeed.

One can argue that once they join the workforce, they will always refer to textbooks and other pieces of information before they submit their work products. So why not allow students to use textbooks or formula sheets (called the cheat sheet) in their tests and exams? I have no problem with this approach for graduate-level classes because the students must possess a certain level of knowledge to quickly open to the appropriate page in the book, but am opposed to open-book exams at the undergraduate level. We are all able

to recite multiplication tables (up to 10 at least) because we use them constantly. Similarly, students cannot afford to forget basic principles in science, math, and engineering. Many students find it difficult to remember fundamental concepts of complex numbers and electromagnetism, and I am not even referring to Maxwell's equations, which are probably off the charts.

Classroom teaching has evolved over the years, and there are some good and bad things about it. Most teachers today have websites created for each class, and the lecture materials are uploaded before the class. PowerPoint slides save time in the classroom; for example, drawings, photographs, graphs, and so forth need not be reproduced on the board. But excessive use of PowerPoint is detrimental to good teaching. This is frequently referred to as "death by PowerPoint." Using the board to explain concepts, derive equations, and solve problems and using PowerPoint slides occasionally is what is generally followed by good teachers, and this is appreciated by students. But in today's modern internet era, everything is posted on the web (solutions to homework assignments, quizzes, tests, and exams) and is available to everyone. Students may browse through these materials and get a false feeling of solving these problems, but in an exam (especially a closed-book exam), they often freeze because they have not done such problems without the aid of the book, friends, and the internet. This, in my mind, separates the good students from the rest. They have good study habits.

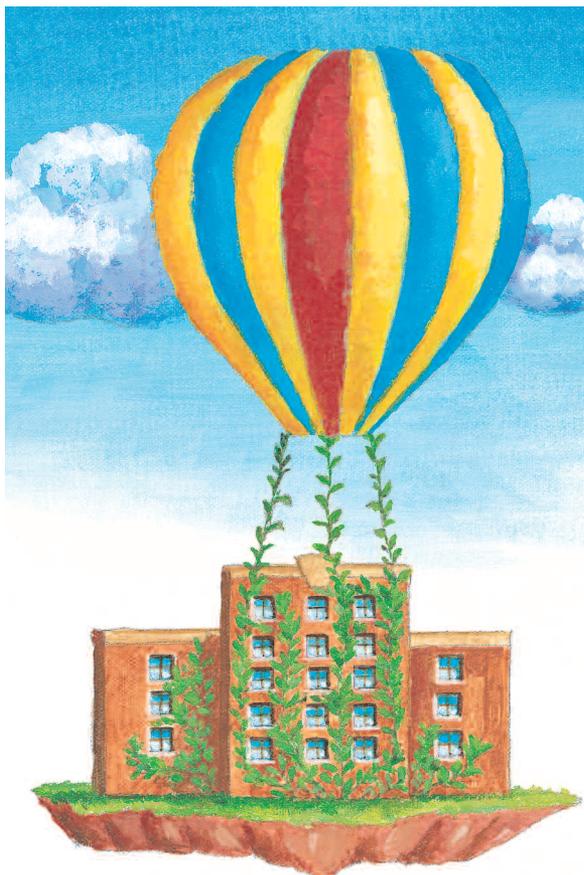
The present practice of students evaluating the teacher should also be examined. Grading in most classes will follow the broad normal distribution, where the class average will be close to the C grade. Student evaluations are usually performed just before the final exam, at which stage students know the score they have earned for roughly 75% of the class work. If grades are not inflated, how do you expect that the average-performing

students will give the instructors “very good” to “excellent” evaluations? These evaluations play a very important part in the promotion and tenure process of the faculty member. The underperforming students will naturally want to move to a different program, one that is not as demanding as engineering. Retention of students within a program and university and their graduation in a timely manner

are important for university rankings in trade magazines.

I recite the following Chinese saying (attributed to Confucius, circa 600 BC) in the beginning of every class, “I hear and I forget, I see and I remember, I do and I understand.” What students do by coming to class and listening to the lecture without taking notes is to hear and see. If they do not actually do the problems by them-

selves after the class, they will not understand. The basic aspects of teaching and learning have not changed, and I doubt that any technology can replace it. Good instructors use the textbook and their work (or research) experience to teach the subject, and good students learn the subject by practicing what is taught in class.



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