2C What Fuzzies Could Learn From Techies [1]

Introduction

Almost all those in academia agree with the value of including liberal arts subjects in order to "round out" an engineering education in order to make a "whole person" of the graduate. Engineering faculty largely agree that engineering students (and faculty) can learn a great deal from liberal arts faculty and their publications, particularly in the valuable area of "soft skills." Through our interactions on campus and the ABET 2000 Criteria we have certainly seen that engineers benefit from interaction with arts/humanities faculty and the materials they develop. Examples include dealing with team members and clients, interpersonal communications, understanding one's abilities and growth areas, communicating concepts to a wide audience, understanding ethical theories, wrestling with ambiguity in those situations which are not clearly black and white, and understanding social impacts of design. Is there a way to return the favor? Not so much consideration has been given to the opposite issue, which is that of helping liberal arts majors to understand some of the technical aspects of our society. Some technical concepts can be communicated with a relatively slight dependence upon mathematical understanding, and these concepts may even be helpful to liberal arts professors in their teaching of liberal arts courses. While there is definitely value in engineers learning something about the liberal arts there is also definitely value to liberal arts majors in learning something about engineering.

Are there some things that "fuzzies" (a nickname heard on National Public Radio for humanities people, apparently popularized at Stanford) might learn from "techies" (NPR's nickname for engineering and technical people)?

Techies tend to be computer gurus, becoming more helpful to fuzzies as our society becomes more dependent on computer technology. In addition to computer assistance, there are also a number of other technical concepts that may be helpful, such as thermodynamic principles involved in economic situations, an understanding of the relative sizes of numbers, and some basic concepts, fundamental to those of an engineering discipline, which can be applied to everyday life. Fuzzies could also benefit from having familiarity with the popular concept of the Singularity (including the controversy that surrounds it) and with Billy V. Koen's "Method." The following pages outline these concepts.

1. Everyday Concepts – Feedback

Our society is continually becoming more technically oriented in all aspects of life. Technology may seem mysterious to fuzzies. There is, however, a certain set of basic, easily understood information that "techies" can help fuzzies understand.

Some basic concepts, fundamental to those of an engineering discipline, can be applied to everyday life. For example, a person concerned about his or her weight can use the concept that "measurement precedes control." This concept comes from the engineering principle of a feedback loop. If the output of a system is used to control the input, the whole system may become stable or unstable. Feedback also occurs when a microphone is placed too close to a speaker at a rock concert. The loud noise produced is due to the instability of too much positive feedback. To control weight, a person may simply count calories daily and record the calorie count on a graph. The individual could also maintain a daily weight record on the same graph. A relationship should arise between these two graphs, and the intake can be adjusted appropriately. Similar thinking occurs in blood sugar control. The individual acts as the feedback loop. Other examples from engineering might include everyday tradeoffs (as in speed/power), "bandwidth", "signal" and "noise" in communication, personal multiplexing (multitasking), opposing forces in society, and reaching "steady state" activity after wild oscillations.

2. Reality and Murphy's Law

Fuzzies would benefit from an understanding of real – world imperfections, so that they would not hold unrealistic expectations of technology.

RWG writes:

Many students today live in a "different reality" than I did. Their "reality" has been influenced by so much TV, video, and computer games that some actually think that these things represent real life. It's as if they had grown up in "the Matrix". They have been immersed in a world in which they have very little experience with reality as dictated by the laws of probability, physical principles, and Murphy's Law. They have learned to expect "miraculous interventions", superhuman strength, and magic. They have not experienced the laws of probability, because very improbable things have become commonplace to them. When I first saw “Mission Impossible”, having been trained as an engineer, I had to laugh out loud, as a complicated device, built without having been tested, functioned perfectly the first time! My sophomore students have to be retrained in the way they build projects, so that they test each part of the device individually before incorporating it in the overall project. This is now necessary in order to overcome their expectation that everything will work perfectly the first time they try it. In other words, they need to learn, by experience, “Murphy’s Law”. One of the projects I assign in lab is to build a Rube Goldberg machine, which is a long string of energy transfers, like the “Mousetrap Game”. The main purpose is to show them that in real life, something will probably go wrong, since real components follow Murphy’s Law. Simply explained, Murphy’s Law says that” if anything can go wrong, it probably will.”

3. Mathematics and Economics

There are some misleading concepts that fuzzies may hold regarding mathematical principles. One example is “Fibber McGee’s law of probability”, which is, “the less you win, the more you gotta.” The radio show, “Fibber McGee and Molly” was popular in the 1940’s. This misconception, that the more often you lose in a game of chance, the higher the probability is that you will win the next time you play, may explain why a large number of people play the lottery, believing that they are investing in their retirement. The problem is due to a lack of familiarity with large numbers and some basic ideas about probability: In a set of independent trials, such as lottery ticket purchase, each round begins anew, so that the probability of winning is the same as it was when you started. If a person “invested” a dollar a day in a lottery that might pay a million dollars, and the odds were a million to one that they would win, then at the end of 40 years they would have lost about $14,600. The probability that they might have won the million dollars at some time during those 40 years is still only one in 68. (proof: multiply 365 days per year by 40 years. Divide by 1,000,000 to obtain .0146, which is roughly one in 68).

Engineers deal with numbers, probabilities, and practical logic, but everyone should be able to manipulate numbers, so that they can make change in a store (without a calculator), or figure out a budget. It is also important to know about the mathematical properties of exponential functions, since almost everything changes up or down at an exponential rate. One also needs an intuition for numbers, so that he or she can make realistic estimates of everyday changes.

An easy way to familiarize oneself with the exponential nature of natural systems is the "rule of 72", which follows, with an example of its use.

The number 72 can be factored in several ways, as 6 times12, 3 times 24, or 2 times 36. Any way you factor it, one factor gives you the per cent compound interest, and the other gives the time it takes for your money to double. For example, if you put your money in the bank at 6% interest, it will double in 12 years. This also works for inflation, in reverse. If the average inflation rate in a country in 6% per year, your money will be worth half as much in 12 years. An engineering analysis of compound interest reveals that the unbridled practice of its use (as debt) can wreak havoc to a society. For instance, one dollar, invested at 1% interest for 2000 years, will yield about 230 million dollars; If the rate is 2%, the yield will be about 50 quadrillion dollars (that equals 50,000 trillion), in that same time period. One can see from this illustration that large inflation rates, or high interest rates, can doom a society. Such was the case in the Weimar Republic before WWII, where inflation became so high that it was cheaper to burn money for heat rather than buy wood with it. A student of the Bible might notice that there was virtually no inflation from the time of Joseph, (who was sold into slavery in Egypt around 1800 B.C. for 20 shekels of silver, roughly 8 silver dollars) to the time of Jesus, (who was "sold" around 30A.D. for roughly the same amount (30 pieces of silver; equivalent to around 12 silver dollars if the pieces are shekels). This is because usury, which is the practice of charging excessive interest, was forbidden in the Jewish Law. We know that "excessive interest" was defined as "the hundredth" (one per cent?), because it was specifically condemned by the prophet Nehemiah (Neh.5:10, 11), in the Old Testament.

4. Engineering Thinking

Computation and scientific thinking may come easily for some students, but many freshman-engineering students don't automatically think like engineers. It takes a few courses to undo some habits learned earlier, so that one can help students consider realistic requirements and constraints, estimate answers rather than blindly accepting calculator answers, and plan out a project instead of jumping too quickly to a supposed solution.

It might help fuzzies to understand the thinking styles involved in engineering design. Engineers typically ask 5 questions at the start of every project:

- What is required?

- How can we do this?
- What will it cost?
- How long will it take?
- How will we verify that we have met the goals?

Engineering design requires alternating between divergent thinking (generating many possible ideas towards a solution) and convergent thinking (narrowing down to the best solution.) Engineers also adopt at least four basic thinking styles or “thinking hats” in design work. Two of these “hats” are positive and creative (“What could be done?”,” How could we do it?”), and two are more negative and restrictive (“Should we do this- are there ethical problems here?”, and “ Is this even possible, given the finances and technology available?”)

5. Basic Engineering Concepts

What would it help fuzzies to know? If we were creating a course for non-engineers, we might include such topics as basic principles behind most devices, mathematics as a modeling language (not as frightening as many think); planning, organizing, considering constraints, and testing as part of everyday life.

Bill writes:
During my time at Drexel, I taught a course in engineering for non-engineering majors, an overview of electrical principles. In that course, I was able to communicate the basics of practical circuit theory and engineering concepts, while I myself learned some basic tenets for communicating technical ideas to a non-technical audience. One of the main approaches is to use analogies to relate engineering concepts to concepts in everyday life. One of the basic foundations of engineering is that physical principles can be modeled mathematically, because they obey the logical laws of physics; however, a person need not be a mathematician to understand the physical principles. Engineers learn to make the relationship between the mathematical model and the physical system. When addressing students who are not familiar with mathematics, the physical principles simply have to be related to other things, which are more familiar to the students. Students need to develop a basic vocabulary in order to begin to

understand concepts, such as voltage, current, inertia, mechanical advantage, and similar terms. When I taught this course in 1970, the emphasis was on electrical engineering, and at the end of the quarter, the students understood frequency, wave propagation, feedback, oscillation, basic electronics, transformers, and broadcasting fundamentals [2]. Since I taught that course I have learned more about how students learn, and there is a marked difference between the abilities demonstrated then and now. Students now tend to be more calculator dependent, less familiar with mathematics, and not as able to focus. [3]

6. Constraints and boundary conditions

Real life deals with boundary conditions at all times. Some things are possible, and some simply are not. It would be a good thing for fuzzies to be able to determine which things are, or are not, possible. The three basic factors that determine this are economic, physical, and technological constraints. Economic constraints involve projects that are possible to develop, but unaffordable within the budget. Physical constraints exist because the implementation of a device would involve a violation of the first or second law of thermodynamics. The final constraint is that the technology to implement a certain design simply has not been developed yet.

Why don't perpetual motion machines work? It is because, by definition, they break the second law of thermodynamics. In common terms, that law translates to "there is no such thing as a free lunch." What are the limits of technology? At what point do we go from science to science fiction; or, vice versa? Many of our present technological advances were predicted in older science fiction stories, and may have even inspired these advances. Some advances did not even seem possible at the time the stories were written. Technological breakthroughs led to their implementation. A great majority of Sci-Fi may never be realized unless faster-than-light travel is possible. So far, it is a scientific limitation. These technical limits can be understood without any technical training.

References

1. Adapted from Graff, R.W., Leiffer, P.R., Batts, M.B., and Leiffer, M.J., "What Fuzzies Might Learn from Techies." ASEE Annual Conference, 2010.
2. Graff, R.W., and Paul R. Leiffer, "Student Observations over the Last 25 Years", Proc. ASEE, June. 2005.
3. Graff, R.W., "Forty Years of Teaching Circuits I: A Tribute to Dr. Hayt" Proc. ASEE, June. 2004.