WHY ENGINEERS SHOULD READ SHAKESPEARE

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Who is in control?

For many years now, CFA has been working with the federal government to develop a rational and scientific-based policy on styrene emissions. To their credit, both parties have accepted reasonable arguments developed by the other party. But this process is not merely conducted by engineers, perhaps not even principally by engineers; it is a process that requires the interaction of lawyers, politicians, health professionals, business professionals, as well as various scientists (including engineers). But who is in control of this process? Up to now, CFA has been able to take the lead, chiefly because of hard work and the development of compelling arguments. However, there may come a time when the politicians and lawyers exert their tremendous power and simply take control. Who will be able to stop them?

We all know about situations where the lawyers and politicians have taken control in opposition to the best engineering evidence. But the purpose of this article is not to complain about the power of non-engineers but, rather, to encourage engineers to take control and develop their own power. They can do it, but not as long as people view them, collectively and individually, as nerds. Who will trust a nerd?

I've thought quite a bit about what it means to be a nerd. I have concluded that nerd is a term that refers to scientists or engineers who are so wrapped up in their own narrow technological world that they cannot relate to the broader world around them. If that definition is true, then it is no wonder that they are laughed at and even more, should not be trusted with major decisions affecting the greater population.

The public not only doubts that nerdy engineers (perhaps all engineers) can really comprehend the world around them but, equally problematical, the public doesn't think that engineers and scientists can even explain their own work. Thus we have scientific reporters who translate technical stories into everyday language. What is wrong with engineers and scientists explaining their own work? We see other professionals like lawyers and politicians explaining their own points of view, why not engineers? The answer, sadly, is that too often engineers have been unintelligible to the common non-scientist. And this has strengthened the general feeling among the public that engineers exist in their own world and haven't developed the skills to communicate properly with the non-technical public.

Even more tragic is the feeling that technology itself has gotten away from the engineers and scientists. Many people believe that lawyers and politicians are more trustworthy in controlling science than are the scientists. Why? Because scientists have too often failed to discuss the broad implications of their science and have made too many errors in judgement about the course of that science.

Scientists must develop the ability to express themselves articulately in terms that all can understand and to discuss scientific and other issues from a broad and comprehensive viewpoint, especially pointing out the non-scientific implications of

scientific decisions. But, the most troubling question we must ask is this ✐ are the engineers capable of such broad and subtle discussions? Are they capable of being leaders? Some are, but are you?

How to take control

I hope you won't mind a little personal reference, but I have closely observed the nerdy tendency in engineers for many years, as I suppose many of you have too. As a university professor in engineering and technology, I am in a position to try to do something about it. (Writing article will also, I hope, be a help.) I believe that engineers too often reject or ignore the type of training that will give them the abilities to become leaders in society.

The process of developing engineers into competent and well-respected leaders requires that two directions be followed simultaneously ✐ depth and breadth. The first direction, depth, implies that the students become good engineers. I help my students in this task by teaching technical courses in composites and plastics. We discuss the behavior of the materials and the processes used to convert these materials to useful products. These subjects can be quite theoretical and, therefore, their understanding requires that the students develop depth in the subject.

In discussing the concepts of molding and finishing of plastics and composites I also try to be very applied because it is in the real-world application of the basic concepts that engineers will spend most of their lives. The engineers must understand engineering fundamentals, but also understand how to apply those fundamentals.

Some engineers believe that this application of engineering science is all that is needed to relate to the real world. Sadly, that is in error. Other skills are needed in the world of commerce

and non-science. Some critical non-technical skills that most engineers need are those of business. Engineers in business need to understand the basic economics of capital justification and pay back. They should also understand simple accounting, marketing, sales, and business decision-making. Not long after they start a job they also find out that writing and speaking skills are also critical to their success. I remember as a chemist at DuPont that my boss suggested that I attend a course on how to write. I did, and it has changed my life. I now spend most of my time writing and talking. Other professional engineers do the same, even when they are not in academics.

As a professor I try to assist my students in gaining business skills by teaching a class that helps engineers start and run their own business. They write business plans and learn many of the skills needed to be entrepreneurs. I am happy to report that many of the students in our program, and many other engineers that I have observed, are anxious to develop these business skills. Sadly, many other engineers believe that if they don't especially like business they will be exempt from needing these skills. I think that they are wrong. Even engineers tucked away in the depths of the engineering department of a large company need to understand how to be effective in the business environment.

I think that still other skills are needed if an engineer is to become a leader of society and take control over their own work and influence the course of society. A colleague and I have written a book that discusses this need. It is called, *Introduction to Engineering Technology and Engineering* by Val Hawks and Brent Strong. Figure 1 is a graphical representation of what we think is needed for a leader of a technology-based business. We have depicted the students as a building that we are helping to construct. The foundation of the building is sound values. This

foundation supports three columns. One is a column of technical capability. Most engineering and technology programs are successful in building a good technical column.

The business column is sometimes built by the university, either in an undergraduate or graduate program, but some engineers, sensing their own deficiencies in the business area, will work hard and learn the business skills without formal schooling, thus creating their own column.

The third column is general education. Universities have long recognized this need for an education beyond just the professional areas (like engineering and business), not just for engineers but for everyone. That is the reason that universities have general education requirements. But I have found a disturbing tendency among engineers to just simply comply with general education requirements and not to seek a real understanding that brings real enrichment.

Therefore, I decided to set an example for the engineers at my school and I began to teach a general education class that satisfies the Western Civilization requirement where the great issues of many societies and times can be examined. My course is called History of Creativity in the Arts, Science and Technology. Although the course is taught to all majors, many who attend are engineers. I try to show them many perspectives that can be obtained from non-technical fields. We discuss creative people and creative periods from the ancient Egyptians, Chinese, Greeks, and Romans through the Renaissance, Enlightenment, Industrial Revolution to Modern times. We look at philosophy, art, literature, drama, politics, music and science. We compare and contrast. When students really get involved in the class, I can see

tremendous growth in the broadness of their views and their understanding of multiple viewpoints. They learn to synthesize new ideas from all the areas we discuss.

Perhaps a few words about the foundation of the building are appropriate at this point. Most people have a good set of values, but I think that these need to be enriched in most engineers. That enrichment comes from considerations of ethical and value-based problems encountered by others in the world so that a person's own values and ethics can be examined more fully and, perhaps, modified. These values might be obtained from religion, from philosophy, or from ethical teachers of other types. Sadly, many people haven't thought deeply about their values or about the values of the society in which they live. Engineers seem to say that they are too busy studying engineering to think about values. Other majors often say the same thing. However, by making a conscious effort to think and discuss values, those values become better defined. Most universities teach courses on ethics, and ours is one of those. In addition, people need to stop in their hurried lives and discuss basic values. Having experience in technical, business, and general education is a great assistance to the ability of people to carry on these discussions in the broadest and most productive environment.

Now, a few words about the roof of the building depicted in Figure 1. It is a roof of creativity. I think that it is the roof because it depends on all the lower parts. Creativity involves being able to think out of a narrow area, sometimes called thinking out of the box. When engineers can think out of the engineering box, they become more creative, they relate more effectively to non-scientists, and they become better people in general.

Creativity involves the process of thinking both **linearly and laterally**. These two aspects of creativity are illustrated in Figure 2. The linear thinking promotes excellence in the

task at hand. This excellence is usually achieved by moving deeply into a subject. It is characterized by hard work, highly developed skills, focus and dedication. Most engineers are quite good at linear creativity.

The truly creative person couples this depth with lateral creativity. This is a leap of concept to a new realm. This leap creates a connection that no one else has ever seen. It is characterized by innovation, intuition, and breadth of vision. In patent work this leap is the unique and unexpected idea. In art it is the creative vision. In engineering it is the development of a brilliant new product or the innovative solution to a lingering manufacturing problem. Such a leap is unexpected and, therefore, does not come from logical thinking. It is, of necessity, non-logical and, therefore, outside the type of thinking that most engineers are trained to do.

This non-logical thinking is not the same as illogical. It is, rather, leaping to a new frame of reference or, using a concept from a different area in a new context that would not be expected purely by logic. The reason is that logical thinking involves expanding a person's knowledge within a particular sphere. This is linear thinking. The leap to a new realm is non-logical, at least at the time the leap was made, and is therefore lateral thinking. Analogies often spring from lateral thinking.

The ability to jump to a new frame of reference is improved as a person becomes more familiar with that frame of reference. It is hard to appreciate the subtleties of a field if you know very little about it. For instance, imagine that you are unfamiliar with baseball. You might not appreciate the subtleties of a finely executed double play. You might not understand the tension that exists in the bottom of the ninth with three runners on base and two outs, the home team behind by three runs, a power hitter up, the count full, and the ace reliever of the other team

about to throw. A knowledge of the game enriches the experience. Knowing about the world enriches thinking and better prepares a person to judge people and events and relate to those whose expertise is in non-technical areas.

Just a brief comment about the enrichment that comes from breadth. One day, about a year ago several of the teachers of the Western Civilization classes were invited to lunch with a visiting scholar who was widely recognized as among the very best Western Civilization teachers in the world. We were asked to introduce ourselves and, when he found out that I was from the College of Engineering and Technology, he moved over to me and quickly engaged me in conversation. He said that he had never met someone from engineering who taught Civilization and wondered why I was doing it. I explained that I wanted to show the engineers and others in the class that engineers could understand the issues of Civilization. He laughed and said that he had sometimes wondered that himself. We had a great talk and, in the end, I realized that we had come to a delightful mutual understanding. I found out that he had written some books about technology and was trying to explain it to non-technical people. He had made efforts to understand the field of engineering, thus trying to bridge the gap between engineering and humanities, just as I was trying to do.

The broad knowledge gained from studying non-technical areas is required to draw meaningful analogies from other fields. Cross-discipline connections are the essence of creativity. Clearly, engineers should develop a broad understanding of the world around them, at least to the level that they can appreciate the subtleties of the other fields and think in the terms used in these non-scientific fields. This concept is represented in Figure 1 by having the roof larger than the areas of the columns. The broad knowledge required for creativity in engineers

comes from technical areas, business areas, and the areas studied for enrichment of values and ethics. Some might say that a person who can do this is a Renaissance Man or Woman.

I have a goal to make all the students in the class Renaissance Men and Women. I believe that the true capability of a Renaissance Men and Women is not just to be broad in knowledge, but, in addition, to have a depth in at least one area. The depth gives a measure of what it takes to really get to the cutting edge of a field, and, therefore, gives a measure of how well other fields have been penetrated.

So, I think that you might be convinced by now of the need for both depth (probably in engineering) and breadth (including business and non-science). But, what is the specific value of Shakespeare?

Why read Shakespeare

The most obvious reason is to acquaint ourselves with, in my opinion, the greatest writer in the English language. Well educated people all over the world are familiar with his works and discuss the concepts and plots from his plays as if everyone present were familiar with them. Hence, a basic understanding of Shakespeare is expected of all educated people. But there is much more. I have read books where Shakespeare's concepts are applied to other fields. For instance, *Shakespeare In Charge*, by Norman Augustine and Kenneth Adelman talks about applying Shakespeare to business.

Shakespeare will help us think. Because we think in words, Shakespeare will help us improve our thinking by enriching our vocabulary. He was the master of inventing new words and, therefore, inventing new subtleties in thinking. Figure 3 contains a list of some of the more than 2000 words invented by Shakespeare. Most experts agree that his works, along with the

King James Version of the Bible, were the most significant forces in defining modern English. The sidebar is a selection from the book *The Story of English* that shows the cleverness of Shakespeare in making phrases in addition to his invention of new words.

Another advantage to reading Shakespeare is his ability to portray human emotions and problems in a variety of settings. For instance, in my class we read *Hamlet*, in part because Hamlet was a college student and I hope that the students can relate to him. Hamlet was troubled because he didn't trust the data he was given. (In this way he was like an engineer who has been given data from the shop floor and doesn't believe it.) Hamlet decided to perform another experiment to try and get an independent confirmation of the data. He was successful but then was troubled with the proper action to take and the timing of that action. When he took the action, he found out that he made a critical mistake. The mistake changed the situation and he had to rethink. Finally, after spending some time away from the problem, he realized the right course and returned to take the action he had newly defined. Sadly, the situation had again changed and the action came too late. I know that Hamlet was not an engineer, but his problems have relevance for us all, both personally and professionally.

Because Shakespeare wrote about so many fields of knowledge, just reading his works will give breadth to a person's knowledge. There are Shakespearean plays about war, rulers, lawyers, spouses, history, fantasies, family troubles, and love ✐ all in rich and lively settings. Even if the play is totally unrelated to your professional area or even to an area that you might need in your professional life, the human dramas enacted will help you in your personal life. And that leads to perhaps the most important point of this entire article.

Engineers are humans

We are all children and most of us are spouses and parents. We all relate with others and sometimes those relationships are with people of integrity and sometimes with people of deceit. Shakespeare helps us see those relationships in strong dramatic terms and, therefore, directs us to better understand ourselves and those around us. Imagine the understanding we can gain from Iago in the play *Othello* when we encounter an associate who lies to try and gain advantage. What about the lessons of marriage that are learned from *Othello* or, more happily, from *Taming of the Shrew*. What about the recognition of higher values than mere competition from *Romeo and Juliet*. What about the lessons of contracts from *Merchant of Venice*. From that play we also learn that when we don't know as much about a situation as others, we are in danger of being taken advantage of.

My wife, Margaret, and I have just seen the last of our children leave the nest. We realized that we needed to develop areas of mutual interest other than our children. Of course, we already had some mutually-shared areas, but we wanted more. We wanted to enrich our lives together. Therefore, Margaret has been attending my class on the History of Creativity. We both knew that it would be difficult for her to develop an appreciation of my composites class; but she could certainly enjoy with me Western Civilization. Not only do we enjoy discussions of the subjects of the class, we also enjoy preparing the lectures together and traveling to the places in the world where famous historical events occurred. We love museums, concerts, and plays and then the discussion afterwards, often with increasing depth and understanding. Even the preparing of this article was a joyful mutual discussion. Engineers might consider developing similar areas of interest and enjoyment with their spouses.

My job as a professor, increasingly, is to suggest that engineers build bridges and even to demonstrate the building of such bridges. The bridges may be between engineering and business or between engineering and industry. They may even be between engineering and the arts and humanities. But most of all, they are between engineers and those who surround them. The question each of you must answer is whether you want to make the effort to build bridges of significance. That takes effort. Perhaps your effort can begin with Shakespeare.
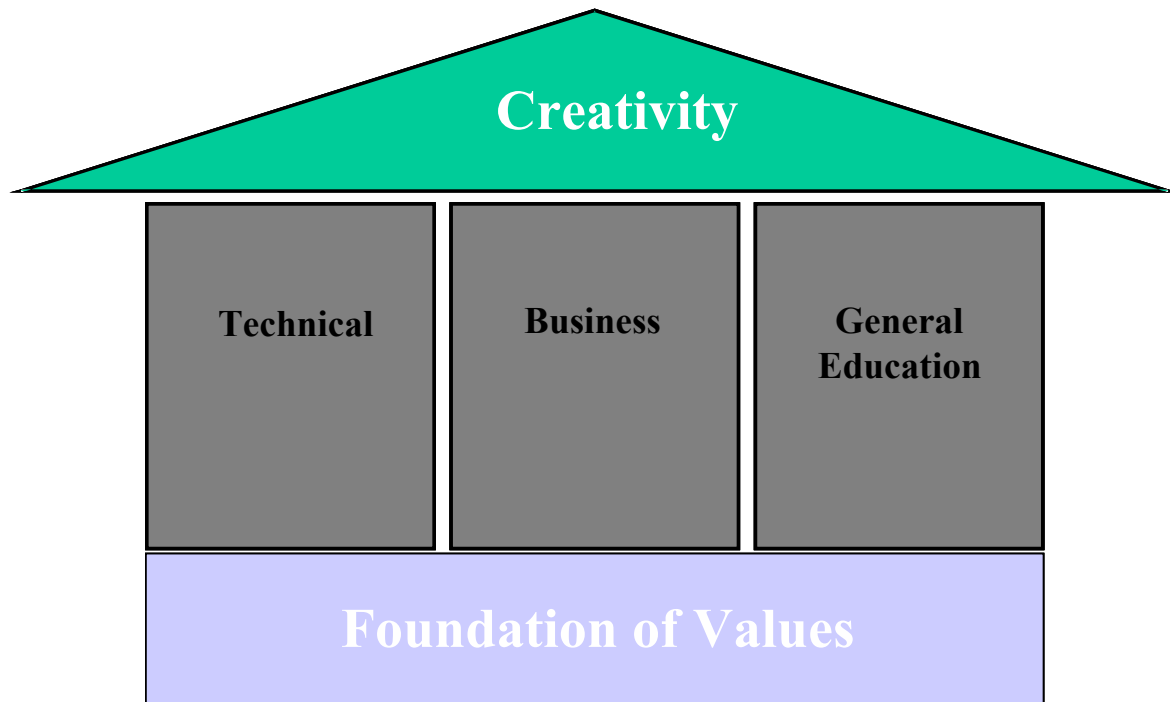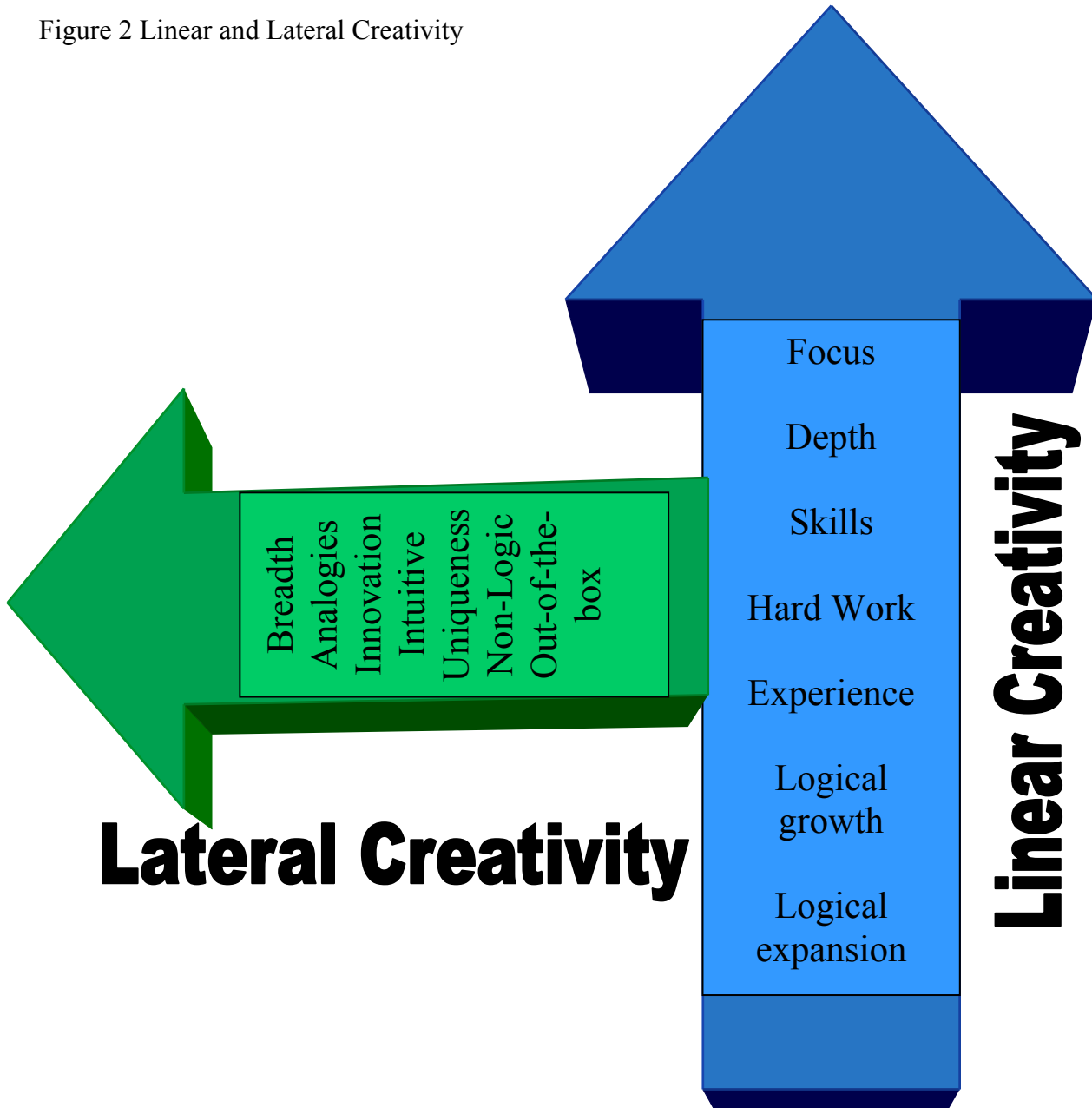
Leadership

Figure 1 Educational Structure to Develop Leadership

Figure 2 Linear and Lateral Creativity

Lateral Creativity

Breadth
Analogies
Innovation
Intuitive
Uniqueness
Non-Logic
Out-of-the-box

Linear Creativity

Focus

Depth

Skills

Hard Work

Experience

Logical growth

Logical expansion

Words Invented by Shakespeare*

accommodation	forefathers	monumental
aggravate	fragment	obscene
assassination	fretful	pedant
barefaced	frugal	premeditated
brittle	guest	radiance
castigate	gust	reliance
countless	hint	snow-white
cranny	homicide	submerged
critical	hurry	summary
dexterously	indistinguishable	summit
dislocate	leapfrog	*selected from
dwindle	lonely	over 2000 total
excellent	majestic	new words

Side bar

Quoting Shakespeare

If you cannot understand my argument, and declare "It's Greek to me," you are quoting Shakespeare; if you claim to be more sinned against than sinning, you are quoting Shakespeare; if you recall you salad days, you are quoting Shakespeare; if you act more in sorrow than in anger, if your wish is father to the thought, if your lost property has vanished into thin air, you are quoting Shakespeare; if you have ever refused to budge an inch or suffered from green-eyed jealousy, if you have played fast and loose, if you have been tongue-tied, a tower of strength, hoodwinked or in a pickle, if you have knitted your brows, made a virtue of necessity, insisted on fair play, slept not one wink, stood on ceremony, danced attendance (on your lord and master), laughed yourself into stitches, had short shrift, cold comfort or too much of a good thing, if you have seen better days or lived in a fool's paradise ✎ why, be that as it may, the more fool you, for it is a foregone conclusion that you are (as good luck would have it) quoting Shakespeare; if you think it is early days and clear out bag and baggage, if you think it is high time and that that is the long and short of it, if you believe that the game is up and that truth will out even if it involves your own flesh and blood, if you lie low till the crack of doom because you suspect foul play, if you have your teeth set on edge (at one fell swoop) without rhyme or reason, then ✎ to give the devil his due ✎ if the truth were known (for surely you have a tongue in your head) you are quoting Shakespeare; even if you bid me good riddance and send me packing, if you wish I was dead as a door-nail, if you think I am an eyesore, a laughing stock, the devil incarnate, a stony-hearted villain, bloody-minded or a blinking idiot, then ✎ by Jove! O

Lord! Tut, tut! for goodness' sake! what the dickens! but me no buts ✎ it is all one to me, for you are quoting Shakespeare.

– Bernard Levin, quoted in *The Story of English* by Robert McCrum, William Cran, and Robert MacNeil, Penguin Books, 1992, pp. 81-82.