Why Scientists Should Read Shakespeare
and
Why Humanists Should Understand Einstein

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When I graduated with a doctorate in Chemistry, I went to work for the DuPont Company and my desire was to focus on plastics and composite materials. As with many aspiring scientists, I hoped to delve deeply into plastics and become a world expert in my field. After seven years and several assignments with plastics products, I had learned much and enjoyed it all. But, an opportunity arose to be the Technical Director for a plastics molding and extrusion company whose products were focused in the drip irrigation market, and so I left DuPont. After only a few weeks, the owners of the irrigation company asked me if I would be the company president. Suddenly my focus changed from technical to business. I had to learn how to be an entrepreneur. I had to study completely new fields – agriculture, irrigation, and business. What a shock it was; and humbling, too. But I was fortunate to have a group of very talented and supportive fellow workers, and our company was very successful. I found the broad perspective both exciting and rewarding.

After about seven years, that company merged with another, and I was out of a job. My wife and I decided to come back home to Utah and after a brief job in new product development, I joined the faculty at BYU. My focus was again on plastics and composite materials. I looked forward to investigating some area of plastics and composites with such intensity that I hoped to see the edge of the forward boundary of human knowledge in my field and I wanted to teach students about what I have learned. What a glorious time it has been.

About 6 years ago I was the Chair of my department, and I was asked to write a position paper on the goals of our department and our place on this campus. After considerable

reflection, I concluded that my department and, indeed, all of Engineering and Technology, were quite isolated from the rest of the campus. We had few interactions with other colleges and taught almost no classes that were taken by students outside our college. I felt that engineers and technologists had some important contributions to make, and we should try to find a way to do it.

This situation disappointed me and in grappling about what to do about it I encountered the Civilization classes that are part of the general education program. I saw that any department could develop a class within the guidelines that had been established for the Civilization courses. Those guidelines stipulated some critical elements of Civilization that must be taught in all the classes, but also allowed sufficient flexibility that, at the time, nine different departments were teaching the course, each with a unique flavor. I thought that maybe I could do it too. But what would be the emphasis? I reasoned that there are many similarities between technology and the arts. I have been told that the word "techne" from which we get "technology" meant both art and craft in the ancient Greek. I also noted that other words seem to cross over between science and the humanities such as Plato's Forms which are remembered in the word we use for mathematical models – formulas. Also, the word "scientist" was invented in the 17th Century as an analogy to the word "artist."

I eventually concluded that one common area for all students is creativity. It is required for all types of people who make significant contributions to our civilization. The examination of creative people and creative periods seemed to be a way to link science, technology and the arts throughout history. It also seemed to be a fun and interesting way to bring diverse groups together in discussion so that they could learn from each other. Teaching that class has been a wonderful experience. It has forced me to again broaden my focus beyond plastics and composites.

Well, that little story was meant to convey a theme that I would like to address in this talk – What are the advantages of having depth in a field and, simultaneously, breadth across many fields? In a sense, that is the question that many students wonder about. "Why should I have to take general education courses? They are irrelevant to what I want to do in life. They're just a series of hoops that I have to jump through."

There may even be some faculty who laugh at my attempts to teach Civilization. They might say that they were not hired to teach outside their field. They might even wonder whether they could successfully learn enough to teach outside their field. (I've wondered that many times myself.) Perhaps with a little defensiveness and also a little encouragement, I want to tell you that great joy can come from learning broadly, whether for students taking GE courses or faculty preparing to teach in areas outside their primary focus.

Along the way in preparing for my Civilization class, I encountered a book by C.P. Snow entitled, *The Two Cultures*. The basis of this book was a lecture given by Dr. Snow in 1959 at Cambridge University on an occasion much like this one. In his book he identified two distinct academic worlds – science and humanities. He said, "In our society (that is, advanced western society) we have lost even the pretense of a common culture. Persons educated with the greatest intensity we know can no longer communicate with each other on the plane of their creative, intellectual and, above all, our normal life. It is leading us to interpret the past wrongly, to misjudge the present, and to deny our hopes of the future. It is making it difficult or impossible for us to take good action." [Snow, C. P., *The Two Cultures*, Cambridge University Press, 1998, p.60.] This is a serious matter. How are we going to progress if vast parts of our society cannot communicate effectively with each other? Will our future be determined by chaos?

Snow used science and humanism as two ends of a spectrum, realizing, as do I, that there

are many disciplines that lie between them, and that this spectrum is an over-simplification. Nevertheless, I hope that you will find yourself somewhere along that spectrum and allow my comments about scientists and humanists to also apply to you in whatever field you may be in. In a way, therefore, my talk is an application of Snow's thesis to today's world, especially to BYU, and in light of my own personal experience.

Isn't it true that part of each person's life experience is an attempt to understand the world around them? This understanding provides personal inner peace and security. The reality is that the world is both technical and aesthetic. Both sides need to be comprehended to see things as they really are. I would, therefore, like to address two propositions which seem to symbolize this divergence in the world: **Why scientists should read Shakespeare;** and**, Why humanists should understand Einstein.**

First, if I may, a few words directed towards scientists. For several years now, a professional society to which I belong has been working with the federal government to develop a rational and scientific-based policy on the regulation of air pollution during the manufacture of composite products. Other parties, such as lawyers, politicians, health professionals, business professionals, and regulatory experts are also interested in this regulation. But who controls this process? Up to now, scientists have taken the lead and all parties have accepted their data. However, there may come a time when politicians and lawyers will exert their tremendous power and simply take over.

My purpose here is not to comment on the power of lawyers and politicians, but to encourage scientists to develop their own power so that, if the decision really should be science-based, they can exert their influence. They can do it, but not as long as people view them, collectively and individually, as being so wrapped up in their own narrow technological world

that they cannot relate to the broader world. And that view is often true. Rewards for scientists are usually related only to their narrow field and so scientists tend to ignore other fields except in a cursory way.

No wonder scientists are rarely trusted with decisions that affect the greater population. The public not only doubts that many scientists can really comprehend the world around them but, equally problematical, the public doesn't think that scientists can even explain their own work. Thus, we have scientific reporters who translate technical stories into everyday language. What's wrong with scientists explaining their own work? The answer, sadly, is that too often scientists are unintelligible to the common non-technically inclined person. They tend to use scientific jargon that is confusing to outsiders. And math is part of the jargon. This tendency has reinforced the general feeling among the public that scientists exist in their own world. (I am reminded of Gulliver's third journey in which he visits an island housing scientists and other elites who float over the real world with little regard for the common people down below. Things weren't so different in Swift's Day when he wrote Gulliver's Travels.)

Equally troubling is the wide-spread feeling that technology itself has gotten away from the scientists. Why? Because scientists have too often failed to see, or at least discuss, the broad implications of their science. Perhaps the most prominent examples are the nuclear bomb and chemical pollution. Scientists have made too many errors in judgment about the broad effects of technology.

Scientists need to see the broad picture and carefully craft reasonable arguments in non-scientific terms that will be persuasive to the general public. These are the skills of the humanists. Scientists need to enter the world of the humanists to be able to adopt their methods. I have chosen Shakespeare as the door to the humanist world.

The question can be asked: What is the specific value of Shakespeare? The most obvious value 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. Shakespeare will help us express our thoughts by enriching our vocabulary and, to the extent that we use words for thinking, our thinking will also improve. He was the master of inventing new words (over 2000). His works, along with the King James Version of the Bible form a basis of modern English.

Another advantage to reading Shakespeare is his ability to portray human emotions and problems in a variety of settings. For instance, in my Civilization class we read Hamlet, in part because Hamlet was a college student and I hope that the students can relate to him. For the scientists in the class, I go through this analysis. Hamlet was troubled because he didn't trust the data he was given. 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. These are problems scientists regularly experience. I know that Hamlet was not a scientist, but his problems have relevance for us all, both personally and professionally.

Because Shakespeare wrote about so many fields, 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, the human dramas enacted will help you in your personal life by providing a broader, truer view.

Scientific discovery is most beneficial when it is applied to human problems. These problems are best understood, and therefore best acted upon, by comprehending the human condition and that requires a view beyond just science.

Now, if I may be bold, I'd like to speak to those in the humanities. Equally tragic to the problems of the scientist in society, is the plight of the humanist in today's world where technology is so prevalent. Where the scientist might think that humanistic studies are **irrelevant** (a statement I have often heard), the humanities student might feel **intimidated** by the world's emphasis on math, statistics, and science (another statement I have often heard). The humanist might also struggle to cope with the complexities of technology. (Perhaps all of us have that problem.) The humanist might even feel depreciated and unheard when facing what seems like a steamroller of science and the scientific method. Even the methods of science – quantitative thinking, modeling, and experimentation – seem vastly different from the humanist methods – form, aesthetics, qualitative thinking, holistic views, and humanness.

Some aspects of the world are best understood with technical language. And, just as there are some words in any language that express concepts better than words in any other language, so too is the technical language. For example, I learned that the word *aguantar* in Spanish has a deep and rich meaning that is not well conveyed in other languages. Similarly, some concepts are best conveyed in technical terms, and we can best understand them when we know the technical language. Such a technical concept is infinity, a concept richly understood in mathematics.

So why should humanists understand Einstein, in particular? First, like Einstein, you must understand classical science. You must appreciate the world described by Newton and the army of other scientists who followed him. For them the world follows laws which describe the

interactions between time, mass, and 3-dimensional space. These interactions are predictable, regular, and capable of being modeled, often in mathematical terms. You must also appreciate that when a problem is too complex, it can often be solved by breaking it down into smaller pieces until you arrive at a piece that is so small it can be solved. That reduced problem is the problem you start with. In the view of classical science, the world is like a clock – regular and predictable – and science's job is to investigate and describe the laws that govern its functions.

After gaining an understanding of classical science, you must then go with Einstein on a thought experiment to explore the outer edges of our existence. You will find that the classical concepts of predictable time, mass, and space no longer apply at very high speeds. You might even travel with scientists who succeeded Einstein into the smallest particles of matter and find that, again, the classical relationships between time, mass, and space do not apply to electrons and other subatomic particles.

Let me give you an interesting thought experiment right now. We now understand that most of the size of an atom is empty space. There are very small and dense nuclei surrounded by electrons which are moving at extremely high rates of speed. But these electrons are a very long distance from the nuclei. Let's assume that we could eliminate the space between the electrons and the nuclei and then gather the nuclei and electrons together like we would gather little tiny marbles. If we did that for all the people living on the earth today, some 6 billion in total, their nuclei and electrons would fit easily into a small drinking glass.

If we understand that the world is mostly regular and predictable, surely we would think of that wall as being solid, but in yet another view, it is mostly empty space. I'll just comment in passing that Christ seems to have understood the emptiness of that space and had the ability to utilize its emptiness when he passed through the wall to visit his disciples after his resurrection.

Humanists who enter the scientific world can make unique contributions. If we are to believe Thomas Kuhn's book, *The Structures of Scientific Revolutions*, all scientific data are filtered through the scientist's paradigm, then scientific output depends greatly on the scientist, just as artistic and literary output depend on the artist or writer. The study of the relationship between artists and their works is clearly the realm of the humanist. Traditionally such studies of scientists have been limited to the history of science, but I believe that if the humanist really understands the science that is being done, then that humanist can make contributions to science itself through a unique and insightful interpretation of the data.

Think about the interesting perspective that humanists can give to understanding models. Scientists use models constantly and treat them as if they are exact when, in truth, no model is exact. Humanists can help scientists evaluate the types of models and even the use of models. We might conclude that models are no more than convenient places for us to hang data. Even more, humanists might have a unique view of statistical probability or of the uncertainly principle, especially as they relate to humans.

Think of the interesting class that a humanist could teach in a basic understanding of scientific phenomena. According to the new general education plan, such an opportunity exists right now for humanists to develop a unique version of Physical Science 100 and of Biology 100. There are, I believe, many other opportunities for humanists to contribute in science if they want to become involved.

The mutual immersion of scientists and humanists into each other's discipline seems to be like traveling to a foreign country. I love to travel and have found that I learn much about another people when I visit them. Several years ago, my wife, Margaret, and I decided that travel would be one of our mutual hobbies. We have found that travel together enriches our lives

personally and deepens our relationship. Along that same line, Margaret regularly attends my Civilization evening class, and she is an active participant in helping me prepare my lectures. Perhaps the scientists and the humanists should visit each other's territories together. They might find new and immensely enriching insights.

Just a comment on this idea of joint teaching. I thought initially that I might team teach my Civilization class with someone from the humanities. I decided against doing that because I realized that I would rely on the humanist for humanist discussions and that I would never really understand their methods and point of view until I took the responsibility for all aspects of the class. However, I visited with several in the arts and letters to help me gain that understanding. I would like to thank, especially, Professors Doug Bush, Wilfrid Griggs, and Tom Plummer for their assistance and insights.

Now I'd like to show how creativity is a basis for much of what I have discussed so far. In my class on the History of Creativity I ask the students to take 30 seconds and write down all the uses they can for a common paper cup. Why don't you take a moment right now and think of a few uses. Some of the uses that are commonly given are: to hold water, to hold lemonade, to hold marbles, to be a vase for flowers, also, to be part of a telephone system with a string, to be a hat, to be a pig's snout in a costume, to be ripped apart as kindling for a fire.

These uses fall into two categories. Some focus on using the cup as a container, that is, its normal function. This is called fluency; and with only a little effort we can logically think of dozens of fluency uses by just varying the liquids or solids that the cup would contain. We might eventually explore the capabilities of the cup as a container by looking at using very hot oil as a liquid and we would find that the cup might be destroyed by such a use. Or, we might put in hexane, a solvent, and see that the wax coating was dissolved. These are logical

investigations. When using fluency, we have a vision of the cup as a container. This is like saying the cup has the Form of a container, in the Platonic sense.

The other uses for a cup examine its applications in ways that were not originally intended. These answers explore flexibility. We see them by analogy or metaphor. They are not logical but, rather, intuitive.

The two types of answers – fluency and flexibility – are really two different ways of thinking. I compare fluency to linear thinking. It is based on logic, focuses on the purpose of the item, and leads to a deep understanding of it. Linear thinking also involves experience and skill. There is creativity involved, but it is creativity supported by logic and hard work.

Flexibility thinking is lateral. This describes uses by analogy and depends on broad, non-logical thinking. It is more intuitive. It seeks uniqueness and innovation. It too is creative. These concepts of linear and lateral thinking were developed by Edward de Bono in his book *Lateral Thinking*, from which I have taken many of these ideas.

After describing these two types of thinking, I realized that they are analogous to left and right brain thinking. One hemisphere of the brain controls logic and gives us fluency. The other hemisphere controls intuition and gives us flexibility. I believe that creativity is best served when both hemispheres are put together and thinking can be both fluent and flexible, logical and intuitive, as needed. Perhaps that is why the halves of the brain are referred to as hemispheres – implying that they are only parts of the oneness of a complete sphere.

Another way to think of our brains is as filing systems. We have file drawers for certain subjects, such as chemistry. When we learn new things about chemistry, we put it into the proper file drawer. Most of our major education is involved in filling up these separate file drawers. But, occasionally we are asked for new and original ideas that require us to make

connections with knowledge in a different field. This is like leaping from one file drawer to another. To accomplish this task, we need breadth so that we have many other file drawers which we can search for an analogy and, in essence, make a leap to or from the file of chemistry.

People can be creative in one kind of thinking – linear or lateral. But, don't we especially appreciate the scientists, for instance, who have unique (lateral) insights within their reporting on the logical (linear) explorations of some phenomenon. Or, the artist that gives us great beauty and aesthetic content (lateral) whose work is executed with wonderful skill and knowledge of the medium (linear).

Here's another example. Louis Pasteur was one of the greatest scientists who has ever lived, spent his life solving biological problems for various French industries from wine making to dairy. He was, during part of his life, investigating ways to cure chicken cholera, a disease that had decimated the poultry business in France. As part of his investigation, he was injecting chickens with a virulent strain of the disease and then, when the chickens got sick, investigating ways to cure them. One day, after a vacation, he came into the lab and noted that a syringe full of the virulent solution had been left out of the refrigerator. Rather than waste it, he used that material and injected several chickens with it. After the normal incubation period of the disease, several days, he found that these chickens were not as sick as usual. He then thought that the virulent material was not good and so he simply re-injected those chickens and some others with new virulent material. After the next incubation period, he was surprised to find that the chickens that had been given two injections were not ill but the others that had only been given the new material were very sick. He thought about what had happened and realized that the previous material that had been left out over the vacation had been attenuated in strength. He therefore seized this opportunity and developed an inoculation against chicken cholera. In

Pasteur's own words: "Chance favors the prepared mind." Pasteur thought linearly in doing the research but used the strangeness of the data as a jumping-off point for lateral thinking. In my class on entrepreneurship for non-business majors, we discuss other situations that might be used to trigger innovation. Besides unexpected occurrences, other situations might be: incongruities, process needs, industry and market changes, demographic changes, changes in perception, and new knowledge.

I submit to you that the ability to capitalize from these innovative moments comes from both depth and breadth. From both linear thinking and lateral thinking. From engagement of both the left and the right sides of the mind. From exploring both our own professional areas and areas outside our fields.

Working on both linear and lateral thinking is hard work. It takes extra effort and much time to learn outside your area. But if you will do it, you will be rewarded with a greater appreciation for others and greater personal creativity. As president Spencer W. Kimball said: "Those tremendously useful men, those powerful and invincible men, Marconi, Edison, Orville Wright, Burbank, who sit wrapped in purple robes of creative genius, are simply men who are capable of striking reiterated blows. They are men who reached success because they subjected themselves to the fierce fires of intellectual and physical endeavor. Men never ascend to eminence by a single leap or by growth overnight. Longfellow gave us this:

"The heights by great men reached and kept
were not attained by sudden flight,
but they, while their companions slept,
were toiling upward in the night."

– Spencer W. Kimball, *The Teachings of Spencer W. Kimball,* Deseret Book, 1982, p. 360.

Too many engineering students come to me with a good idea and want to form a company around it, but they don't have any appreciation for the business side. They think that the world will beat a path to their door just because the product is a good one. Equally sad are the many business students who come to me with the idea for a product but assume that making it is trivial and they haven't any idea about how that will be done, or the costs involved.

We all need to explore the territory of others. That is true for both students and faculty. A liberal education has always involved studies in both the humanities and the sciences. This was true in Aristotle's Lyceum and throughout the Middle Ages when the trivium and quadrivium were the curricula for a proper education. Today we have general education which is hoped to give the broad perspective and to encourage life-long learning across many fields. I think that the concepts of general education and life-long learning should apply to faculty throughout their careers; just as they apply to students. Breadth will help the faculty in their own lives, and they will be better mentors and examples to their students.

The separation of our disciplines has occurred, in part, to facilitate logical development of each discipline and to allow us to teach the vast amount of knowledge accumulated in each discipline. But maybe we should be less concerned about content and more concerned about how to think creatively. We believe that proper rigor in the field requires depth. Maybe we ought to rethink the definition of rigor. Also, because the faculty are currently promoted on the basis of their research contributions, that places a premium on depth. We might rethink that also.

The world, too, is compartmentalized so that we can contribute to a specific field that probably requires skill and training – both of them linear in nature. However, I would like to read a quote on this matter from Gerald Zaltman, Professor of Business Administration at Harvard.

> "I don't buy the notion that the world is organized the way universities and companies are. Ideas don't know what discipline they're in. We might kidnap them and say, 'That's a marketing idea' or 'That's an anthropology idea.' But if you walked up to an idea on the street, it wouldn't know about that." (Personal communication, October 2003)

I believe that exploration of areas outside your major, by both students and faculty will be especially rewarding for BYU and will greatly add to the aims of a BYU education. We would increase our understanding of the worldwide church, capitalize on the missionary experience, improve BYU's ability to appropriately change with the times, and be more creative. I believe that if our students are to be leaders, they must have vision. That requires depth to see the future and breadth to understand the implications of that future.

Some good things are already underway at BYU. Several colleges have united to form a Center for Creativity. Those colleges include: engineering and technology, fine arts, business, education, humanities, general education, and the museum of art. We are working hard to cross the normal academic boundaries.

I believe that non-scientists will be enriched by thinking and acting in scientific terms – quantitative thinking, use of models, objective viewpoint, reductionism, experiments, mathematics, and determinism; just as the non-humanist will be enriched by thinking and acting in humanist terms – qualitative thinking, use of forms, subjective viewpoint, holistic consideration, technique, aesthetics, and diversity. Creativity is one bridge. Other bridges are: critical thinking, symmetry, beauty, technology or technique, and simple elegance. Scientists tend to think in terms of absolute models, trying to avoid thinking about the deviations. Humanists also think in terms of models, often called forms, but are quite happy to deviate,

especially to demonstrate individual creativity. This is clearly an area where a meaningful dialogue would be beneficial to both parties.

I think that we will be personally enriched when we make the effort to take trips into the foreign territory of other fields. When we do, we will gain a greater appreciation of their thinking, methods, and understandings. Remember that the phrase "narrow mindedness" implies less than the entire scope of thinking. It is constricted and divisive. As we gain knowledge in these other fields, we will likely enrich work in our own field because of our increased ability to think laterally. But, we may also make meaningful contributions in the new field, especially if we are taking that tour jointly with someone from that foreign territory. Imagine the creative output that might emerge had Einstein and Shakespeare collaborated.

The Lord has said that Zion consists of people of one heart and one mind. I don't think we can do that without understanding each other. I pray that we, students and faculty, will make the effort to understand fields outside our majors at much deeper levels. I hope that students will take the fullest advantage of this breadth opportunity through their general education requirements and then will continue to actively explore foreign territories, literally and figuratively, for the rest of their lives. I also hope that the faculty will do likewise so that they can be examples and mentors for the students in this wonderful and enriching experience of life. This I pray in the name of Jesus Christ. Amen.