Peter T. Kissinger,
Bioanalytical Systems and Purdue University, 2701 Kent Avenue, West Lafayette, Indiana 47906 USA

Thoughts on Science Education

This article is the writer's thoughts on how to improve K-12 science education, based on 40 years of his observations of what works and what doesn't. He makes no claim to being an expert, only to being an interested observer. Refuting much of the negative thought about the current state of education in the United States, the writer notes the many talented and dedicated teachers and students who perform at the highest levels with the full support of their families and the business community. On the other hand, he concludes that we can do far better and outlines ways in which science education can be improved.

Parents Learning with Their Children

Science is hard only for those who are not curious. I believe the most important component of science education is parents who are curious and educated about science. How things work is an excellent subject of dinner conversation. Parents who are not curious about microwave ovens, cell phones or modern medicines are likely to have children who also lack curiosity.

Anyone can participate in learning throughout their lives. Now that we have the Internet and tools such as Google, you can push a button and find fabulous introductory material on just about any subject. One reason immigrants appear to excel in science and engineering is that they are curious, and they see how being curious can make them successful. I suppose they were curious about coming to the United States and overcame their cultural fears of doing so. We should admire this tenacity and be inspired by it. We have been taking advantage of this quality since the early 1700s and we should embrace it, not see it as a threat.

Study the History of Science

Science evolved (pun intended) from the curiosity of amazing individuals. By studying the way they thought and worked many hundreds of years ago, you can gain a great understanding of how we arrived where we are today. In my field, people like Luigi Galvani, Alessandro Volta, Humphry Davy, Michael Faraday, Louis Pasteur, J.J. Thomson and Linus Pauling (who I met several times) provide fascinating insights to how our thinking evolved. (Biographies of these folks are readily available.) These pioneers regularly struggled to gain acceptance. Some even cheated along the way or took more credit than they deserved. They were human and had all the foibles that entails. We often imagine that scientists and engineers are somehow different from the rest of us, don't have fun and live rather boring lives. On the contrary; they are a pretty wild bunch and very capable of the sins practiced by all other professions.

Big Picture Topics

In the 1960s there was great excitement about plastics, space exploration, solid-state electronics and more effective drugs. Today there are global strategic challenges with respect to energy, the environment, basic life sciences and translating research to improved healthcare. Students like to grasp the important things. They want to believe they can make a difference. Giving students a feel for these big topics can get them thinking about why understanding the details of science will repay society many times over. A recent example is the fad to study forensics. Enrollment in college courses on crime scene investigations matches the excitement created by television shows in this area. If this inspires students to learn some key technologies, so much the better. Memorizing the periodic table of the elements, more than anything else, has probably driven many potential scientists to become lawyers or accountants.

Less Is More

The amount of material in modern science textbooks is inconsistent with the time allowed to digest it. This may result from the difficulty of deciding what to include and therefore including everything. I suspect that textbook publishers are co-conspirators. We simply do not need all these books any longer. A modular approach using shorter texts with supplemental material provided by individual teachers is much more effective and economical.

If a goal is to convince the majority that science is too hard, too dry, and only for "brainiacs," then we are very successful. On the other hand, learning a few basic concepts very well would be better than learning nothing at all. Topics commonly encountered in every day experience is a good place to start. For beginning students, a feel for acid-base chemistry and the properties of solvents could be judged to be far more important than studies of obscure radioactive elements or the structure of crystals. What is studied is less important than learning how to study.

School Choice

Science means experiments, testing ideas. Education should encourage the same. The very concept of national or statewide standards implies inflexibility and mediocrity. Concepts such as "no child left behind" are worthy, but in the extreme they deny that humans are like snow flakes, everyone different. Choice allows for experiment with specialty schools that try

some things in new ways that might later influence all schools. No two students are alike; treating them as if they are makes little sense. Choice brings quality. Fear of choice is the fear to experiment.

Year-Round School

The current school year is archaic. There are many macroscopic factors that make it so, including the rise of women in the workforce, the dramatic reduction of workers devoted to mechanized agriculture, and the invention of air conditioning. Year-round school is one of those topics for experiment. We should pioneer it in a few more school districts and get the bugs worked out.

No More Class of 20XX

The very notion that everyone is the same is absurd in a society that espouses the virtues of diversity. We are not the same; we are diverse. Why would we all be expected to get to the same place at the same time? Some of us will go faster. Some will change direction along the way and be inspired to a new course in the middle of it all. High school can easily be a 4- to 6-year experience. I'm encouraged by the notion of a smoother integration of high school with community colleges. Yearbooks are an anachronism, a money-making scheme for photographers and nothing more. Let's give students a choice of speed, location and subject matter.

While this is a federal issue in a legal sense, we clearly can lead by example on the local level. Our federal government is unreliable in this respect. We should just do it! I'm tired of needing two sets of socket wrenches. Clearly we are now in an integrated global economy, and this is not a topic with which we distinguish ourselves by being different from the rest of the world.

Pay for Degreed Science Teachers

It is well known that science in the U.S. is often not taught by those who majored in a specific science at a university. Taking a chemistry class or two does not make a chemist. While it is true that the most brilliant Ph.D. scientist would likely be clueless about how to manage a class of 14-year-olds, it is equally true that it doesn't do us much good to be able to manage a class but not convey excitement for the subject at hand, or not to have adequate knowledge of the subject. Both are needed. We need to overcome the apparent fear of differential pay for merit and deal with the fact that our society values some things more than others. Competition is a good thing. We have salary differences in many professions, and we ought to consider the same for the classroom. Clearly mistakes will be made and some decisions will be wrong and "unfair." That's how life works. If we don't step up and try for excellence because we fear making a few mistakes, we will never achieve it.

Science Vans Are Smart

Most schools do not have the scientific equipment necessary to get students engaged with modern laboratory tools. Keep in mind that science is not about Bunsen burners and test tubes. Those things are for science history (see above). Science is about curiosity. It is about electronics and software and spectrometers. Scientists use measurement devices that are not affordable, or even justifiable, to use in a high school two weeks out of the year. The technology advances too rapidly. But when several schools share scarce resources we can give the students a more modern experience and spread the cost.

A scientific instrument project at multiple sites throughout the State of Indiana has been proposed. This would educate high school science teachers in the use of modern instrument technologies for making scientific measurements and deliver first-class sets of scientific instruments to their schools for hands-on experimentation in the classroom. This is not a new idea. It has been well established for over 15 years in several states, including Indiana, where it was first prototyped at Purdue University, inspired by a program in Pennsylvania. (Ben Franklin would have loved the idea!) This is smart funding for school science, smart for business, and it can fire up the students. Not to have this is to short-change students. The more young people see modern science, the more they will want to participate. **F1** illustrates the reality of this program at Purdue.

F1. Purdue's Science Express science van

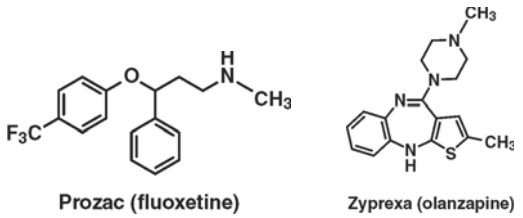
Newspapers Could Become Science-friendly

Science is hard only because we make it so with complicated jargon. The same is true for football. I suggest we give an award to newspapers that would do such things as begin to use the metric system when mileage is indicated, and to show a chemical structure now and again. Parents and children alike don't absorb science because they don't see it. Organic chemical structures don't have to be hard. They can be fun. Why not show the chemical structure of a drug or an environmental contaminant? It's easy, and in a few years many would become more science-literate, just as they become more football-literate from watching and reading about it.

I suspect the problem is that there are fewer science journalists than science teachers. Science is a liberal art. Liberal arts majors who don't know science at all are ignorant of much of what moves society along. How can they be enlightened? They have an iPOD and know nothing about the battery that powers it? They take an anti-hypertensive drug and can't imagine the C, H, N, O, S in its structure. Are they not curious? **F2** shows structures for Prozac and Zyprexa. These

two drugs alone have brought many tens of billions of dollars into Indiana and are responsible for funding art museums, orchestras, universities and private colleges. You'd think we'd all want to know where this largesse came from. It came from science!

F2. Prozac and Zyprexa molecular structures.



Teach Local Science

I find that students really enjoy (and can grasp and remember) the commercial science in Indiana. At every opportunity I talk about what DowAgro does for agriculture. I show students the nifty glucose meters from Roche Diagnostics that you can buy at any pharmacy or Wal-Mart. These meters are fabulous teaching tools, and there are not many sophisticated digital chemical instruments that, like them, are available for the price of an athletic ticket. Do our students really know what diseases Lilly scientists have helped ameliorate? Indiana is a mass spectrometry capital. Do you know what mass spectrometry is and why it's so important at Notre Dame, Purdue, Discovery Park, BASi, the School of Medicine, IU-Bloomington, Endocyte, SSCI, Lilly, DowAgro, Griffin Analytical, Prosolia? You don't! Why not? Every state has commercial sciences that can help make academic science real for parents and students.

Field Trips

While science vans help a great deal in closing the gap between science history and science in reality, they can't get us all the way there. That's unaffordable. Still, it makes a huge difference to know where you are heading so you can set your compass. Kids can see athletes play and be motivated to try to do the same. Children who get into modern factories and laboratories are likewise inspired. At BASi we like nothing better than to show students our research instrumentation and how we make our products. Boy Scouts, Girls Scouts, Junior Achievement, 4-H-ers, and the like can get a feel for how things look beyond school in a scientist's or engineer's life. Nothing is more important. My colleagues in business who say, "This is a nuisance," or "It costs too much," or "A kid might get hurt" are short-sighted and may be the first to complain about unprepared new employees. They likewise will say the children in China or India are smarter. Baloney! Stimulating young people to learn is far too important to leave entirely to the schools. Schools cannot do it alone.

Conclusion

There are many things that can be done right now to help with science and engineering education. Many of them involve experiments and, thus, change. Until we embrace change instead of fearing it, we will get the same unsatisfactory results year after year. Albert Einstein is credited with having said that insanity is doing the same thing over and over again and expecting different results. I agree with his assessment.

A variation of this article appeared earlier in Business Voice (May/June 2006), a publication of the Indiana State Chamber of Commerce.