Adrift in a Sea of Numbers

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President Anderson, Dean May, faculty colleagues, regents, donors, parents, friends, and students: I congratulate today's honorees and I especially acknowledge the support of your parents, grandparents, and teachers. This is a day for all to enjoy.

In thinking about this occasion, I have been struck by the paradox of celebrating academic achievement at a time of economic collapse. The contrast between the accomplishments of our students and the failures of our financial system is especially ironic because today's economic crisis appears to have been brought on by yesterday's honor students.

We all recall the reasons offered for generous Wall Street bonuses: they were needed, so we were told, to retain the "best and brightest." Those of my generation associate this phrase with the sardonic title of David Halberstam's chronicle of the Vietnam war. I can't help but wonder why it is that yesterday's tragedy and today's crisis were both enabled by former honor students.

Vietnam was a complex geopolitical issue in which I have no special expertise. But the esoteric financial instruments that crashed the world's economy are essentially just theorems about numbers—things I do know something about.

Financial contracts, like theorems, are just complicated if-then statements: if you do A, I'll do B, and if I do C, then you must do D. The money controlled by these contracts is not silver or gold, or even printed bills, but just digits in computers. When a bank in Shanghi transfers money to a bank in New York, it doesn't load currency on a boat. Its computer simply tells the New York bank's computer to add a few numbers to its electronic balance sheet. So to understand the financial crisis, we need to understand how numbers behave.

The same is true in many other spheres. We are all awash in a sea of numbers that increasingly influence our lives.

- *Would closing our border with Mexico help slow the spread of the novel H1N1 flu?* The answer depends on incubation rates, transmission rates, and mortality rates, each of which require emerging data of uncertain reliability.
- *Will we ever know who really won the Minnesota Senate race?* Apart from disputes about which ballots are legal, what procedure can guarantee no errors in counting 3 million ballots? Can better election law ever eliminate all errors? If not, how should we deal with close races?
- *Can more testing improve K-12 education?* For the last eight years teachers and schools have been judged on student test scores in some three dozen demographic categories at several different grades. So far the only clear result appears to be increased controversy.
- *What can DNA tell us about evolution, disease, and life itself?* Major parts of biology have been transformed into numbers by the digital science of bioinformatics whose algorithms help decipher DNA. These billions of bits constitute, in the words of geneticist Eric Lander, "the most remarkable library of information on this planet."
- *Why is politics increasingly partisan?* Many blame the ability of data-mining software to fine-tune political campaigns and district boundaries to partisan advantage.

So who can make sense of all this data? We used to have an easy answer: honor students. After all, aren't they our best and brightest?

But now we have to pause and think—just as Halberstam did after Vietnam. How can things go so wrong even when managed by bright and talented people? Just how did yesterday's honor students manage to bring down Wall Street? Might their fancy methods also bring down education, or biology, or democracy itself?

Since everything these days seems to be influenced by numbers, it may be helpful to examine the Wall Street experience to see what we can learn about how numbers behave.

I need to begin with a *mea culpa*: the folks who invented the fancy contracts that led to the economic crisis were trained primarily as physicists and mathematicians. The infatuated business press calls them "quants"—bright new Ph.D.s recruited by Wall Street to develop the mathematical models that make global finance possible.

However, it is not models but people who business decisions—executives, managers, politicians, journalists, investors. Even the decision to delegate a financial transaction to a computer program is made by a person. Typically, those making the most important decisions are liberal arts graduates who often find themselves swamped by a sea of data that they do not fully understand. Although literate, many are insufficiently numerate.

New York Times columnist David Brooks recently summarized various hypotheses about the financial crisis in a single question: Was it greed or was it stupidity?

Those favoring greed argue that the quants were overruled by managers who ignored the limitations of their models. In this view, executives, journalists, and politicians drew conclusions about risks without first verifying that the assumptions underlying the models had been fulfilled.

Those arguing for stupidity claim that it was the quants themselves who did not get things right. Not even the best and brightest can create models that accurately measure future risk. Brooks sides with this view, and I am inclined to agree. As complexity increases, so does intrinsic unpredictability. Eventually, complexity tips the balance away from what were famously called "known unknowns" to the *terra incognito* of "unknown unknowns."

That's bad news for decision makers—not just for bankers, but for anyone who relies on computer data as the basis for decisions. Which teachers to retain, which cities to quarantine, which tax cut to support, which health plan to adopt—all these decisions depend on computer models that are at least as complicated as those that failed us in the financial markets.

Faced with a daily flood of numbers, we latch onto simple indicators for guidance: inflation rates, graduation rates, stock market averages, unemployment rates. Numbers such as these, reported endlessly, become <u>mindless totems</u> that guide our lives through a data-drenched world.

Unfortunately, whenever we reduce complex systems to single numbers we misrepresent reality. A prime example is variability—what economists call risk and scientists call error. Unknown variability, it turns out, was probably the source of Wall Street's collapse.

The quants' models drew on powerful theories that had been honored with Nobel prizes. But these theories assumed that markets vary in certain ways, typically like the bell-shaped normal distribution.

However, not everything follows this law—especially not human behavior. The so-called "black swan" hypothesis posits that extreme financial events are much more likely than would be predicted by the normal distribution.

We don't have enough experience to properly estimate the variability of financial risk. Moreover, large complex systems are inherently chaotic and beyond our power to predict. Like the atmosphere, financial markets can have their own "butterfly effect."

I'm sure the Wall Street quants knew all this, at least intellectually. They are, after all, among our best and brightest. But they became infatuated with the power they held over numbers and ignored what they did not know.

The ancient Greeks had a word for this: hubris. Later today at the Science Symposium on "New Technologies, New Decisions" we can learn about some other opportunities for hubris—in this case, in genetic engineering.

The Wall Street example of the best and brightest brought low by hubris is not just an ironic paradox, as I first thought. It is also a particularly apt lesson for all of us at St. Olaf since it teaches, as well as any lesson can, the importance of a liberal arts education.

Since we can neither master every number nor comprehend fully every complex system, we must cultivate the habit of examining data from multiple perspectives. Ask hard questions of the numbers you encounter: don't ignore numbers, but never take them at face value. Always connect them to insights from other sources.

Perhaps more memorable is the alliterative language used in the design the new Regents Hall of Natural and Mathematical Sciences. To make numbers meaningful, adopt a perspective that is interdisciplinary, investigative, interactive, and interconnected.

That's the very best way to honor your liberal education—and to stay afloat in a sea of numbers.