Opinion

For Whom the Bell Tolls

The mathematics profession faces new and disturbing challenges. We must consider how to maintain and propagate our numbers. Fifty years ago the student who had a proclivity for strict analytical thinking naturally gravitated to a career in mathematics. The curriculum held few other choices that offered the rigor and the challenges of classical mathematics. The situation has now changed.

Today the student with mathematical talent can consider a career in bioinformatics, genomics, proteomics, financial derivatives, biostatistics, biomedical engineering, computer science, and—well, need I go on? Gone are the days when a student with mathematical training could only teach. The choices today are copious and baffling in their diversity and their myriad rewards (pecuniary and otherwise). Mathematics does not compete well in the marketplace of high-impact, money-driven pseudodiscourse. Couple this with the fact that we have never been any good at selling ourselves, and we clearly have a significant conundrum.

And the American students that we do attract do not seem to have the fire-in-the-guts that perhaps you and I had thirty-five years ago. When I went off to graduate school, I knew that this—getting a Ph.D. in mathematics—was something that I *had* to do. If I could not do mathematics, then I did not care what I did. I rarely see this sort of passion in today's students. American students especially seem to be bewildered, and therefore their focus is diluted, by the plethora of life choices that they face.

Today's students have grown up in an age of intellectual relativism that suggests that marketing software or cloning a gene has the same *gravitas* as proving a theorem. If people can think that chaos or data mining is actually a subject, then how are we to sell intersection theory or singular integral operators? The fact that mathematics builds vertically often works against us. It means that we have a hard time integrating students into our research programs. And it means that we have a difficult time showing our students—even our graduate students—the delights and compensations of the mathematical life.

Yet teaching and training graduate students remains one of the highest and finest things that we do. There is hardly anything more satisfying than bringing a student from the level of an ill-formed tyro to a polished scholar who is equipped to create mathematics and chart an independent path in the mathematical firmament. But we are not expert at this process. We know how to hand out thesis problems, we know how to answer questions, but how many of us really know how to *mentor*?

Today we have difficulties retaining students in our graduate programs. Every great religion has a vignette in which the prophet is tempted by mammon, and the prophet usually resists. Our graduate students do not come from such stern stuff, and their temptations are many. When faced with a future that consists of five years as a graduate student, six years as an assistant professor, another six years as an associate professor, and then a long slide toward the grave in a full professorship, the faint of heart will seek other rewards. When the economy is good, a student can major in computer science and get an M.B.A. in a total of about six years and then go off to a well-paying and reasonably rewarding career. Who needs the high-flown rodomontade of classical scholarship?

I, for one, would argue that scholarly work has intrinsic merit. The battle with ideas, the thrill of the pursuit of a new truth, the taming of a beautiful new proof are without parallel in human experience. Yet who among us can instill this euphoria and the passion for it in our youth? Laboratory sciences have much infrastructure, and they assist their students through each step of a graduate program. We mathematicians assign our students a great deal of independence (thinking they are like us), and as a result we lose many along the way.

The path to an established career as an academic mathematician is a long one, fraught with peril. But the rewards are many, it is a satisfying life, and there is frequent serendipity in the practice. It is challenging to find ways to present the old ideas to a new generation of students, it is gratifying to see their eyes light up when they encounter a new idea, and training new scholars works symbiotically with the process of conducting one's own research program.

One of the comforts of my life is that I have many choices. I do not have to remain a university mathematician. I have other skills. But I cannot think of anything I would rather do. I enjoy being a recognized expert in several areas of mathematics, I enjoy being consulted for my erudition, and I enjoy being a leader in my profession. I am pretty good at what I do, and I like doing something at which I excel and that is recognized by others. This rapture is what we must teach our graduate students. The point of our profession is the sheer *joy* of being a mathematician. If we cannot communicate that to our progeny, then what good are we?

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Letters to the Editor

The Financial Industry

I have worked on Wall Street for over twenty years, and I have been a regular reader of the *Notices* for many years. It was therefore with interest that I began to read an article on the recent accounting scandals by Mary Poovey in the January 2003 issue. The article ostensibly sets out to criticize the financial industry's use of numbers. In reality, the article takes random potshots at various financial instruments and practices. As I read it I found so many innuendos, unwarranted conclusions, and fantastical elements that I had trouble selecting just a few examples for special criticism; here are three:

1. "At the time Enron was doing all this, of course, all of these instruments, including derivatives, were perfectly legal. Derivatives were developed, in fact, specifically to take advantage of deregulation, which also permitted creative accounting to flourish."

These statements seem crafted to give the impression that derivatives and such instruments were once illegal but are now legal because of deregulation. They are not and never were illegal. Furthermore, derivatives were not developed to take advantage of deregulation. They were developed and sold as a means to reduce investment risk. Far from requiring deregulation, the trading of derivatives demanded orderly markets, which is possible only with regulation. Options trading is regulated via the exchanges which trade them and via the Options Clearing Corporation (OCC; see `www.optionsclearing.com`), which acts as a clearinghouse and as a licensing authority over exchanges. All these in turn are tightly regulated by the Securities and Exchange Commission (SEC; see `www.sec.gov`). Commodity futures are directly regulated by the Commodities Futures Trading Commission (CFTC; see `www.cftc.gov`), a federal agency.

2. "Because of their notional quality and because of the secrecy in which they are typically traded, the volume of derivatives is difficult to measure…."

Derivatives are not traded in secret. Options and futures are traded on well-known public exchanges. For example, the Philadelphia Stock Exchange (`www.phlx.com`), the Chicago Board of Options Exchange (`www.cboe.com`), and the American Stock Exchange (`www.amex.com`) specialize in trading various forms of options and are all registered with the OCC.

3. "Axis of power."

This is a recurring theme in the article. It has nothing to do with the avowed goal of the article. But the words evoke powerful emotions, conjuring up the "Axis Powers" of World War II and more recently President Bush's "axis of evil". Given the general tone of the article, one wonders whether this might not be deliberate.

Far from writing an article to criticize the use of numbers in finance, Mary Poovey seems to have written an article to denounce an imagined, fantastical power in the world, which indirectly through proximity in text, use of pejoratives, misdirection, and inappropriate references she associates with the world of finance. That she did not make her point of view explicit shows that she lacks evidence to support her implicit accusations.

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Models for the Genetic Code

The human genome has been described, as have the genomes of the fruit fly, yeast, and hundreds of bacteria. Many research centers are extending these results and interpreting the resulting data. In view of the fundamental importance of DNA sequences, it is remarkable that mathematicians have not made more of an effort to introduce and study models of the genetic code.

DNA sequences which perform a function—protein sequences are an important example—are generated by enzymes and hence by a chemical rule. The notion of recursiveness is very broad and surely can describe any sequence of chemicals. Protein sequences, and other DNA sequences, must be recursive. What recursions occur?

What is the linear structure of the genetic code?

The four-letter code for DNA consists of T = thymine, A = adenine, G = guanine, and C = cytosine. We can model these with any of the rings with four elements: Z_4, $Z_2 \times Z_2$, $GF(4)$, or $Z_2[t]$ with $t^2 = 0$.

If we choose Z_4 as a model, we can set $T = 1$, $A = 3$, $G = 0$, $C = 2$. The involution $x \to x + 2$ models Chargaff's Rules, $T \leftrightarrow A$, $G \leftrightarrow C$, which say that in the double helix thymine is always paired with adenine, and guanine is always paired with cytosine.

Computer codes are often constructed by taking a linear recursive sequence (shift register output) and modifying it. Does the cell do this? Which of the four rings above gives the best model for DNA sequences?

The linear structure of the genetic code is Terra Incognita.

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