Supporting a National Treasure

It is a sunny July afternoon on the campus of Hampshire College, and the five o'clock "Prime Time Theorem" talk has just ended. The talk is part of the daily ritual for the high school students participating in the Hampshire College Summer Studies in Mathematics (HCSSiM). A group of students ambles toward the dining hall with the speaker, James Propp of the University of Wisconsin, who works in probability and dynamical systems and is an HCSSiM alumnus himself. Propp's talk had finished with a picture illustrating ideas from his current research. He remarks that it would be nice to have an animation showing the picture developing so that one could see the patterns emerge. By the time the group wanders back to the computer room after dinner, one of the students, Peter Fidkowski from Macungie, Pennsylvania, has already written a little Basic program to produce the animation. The speaker and a gaggle of students crowd around the computer to watch the picture unfold.

This alacrity in pursuing mathematical ideas as they arise is just what the HCSSiM tries to foster. "It's so different from high school," says Jake Gottlieb from Scottsdale, Arizona. "Here you are with a lot of kids who are interested in the same things you are." He finds his high school mathematics classes boring and repetitive, the work in the summer program new and challenging. Students in HCSSiM must take much more initiative in their work, for the goal is not to cover material but to really understand mathematical ideas. "Whatever you put into it, you get out of it," Gottlieb remarks. The students rise to the occasion with great enthusiasm.

Programs like HCSSiM are national treasures that need to be supported and nurtured, and this is the purpose of the AMS Epsilon Fund. The name derives from Paul Erdős's predilection for calling children "epsilons". The fund, sustained through contributions by AMS members, makes small grants to support student scholarships for such programs. Over the past four summers, thirty awards totaling $315,000 have been made. Last year about 1,500 AMS members generously contributed to the fund.

For the summer of 2003, eight programs, including HCSSiM, received Epsilon grants. The other programs are: All Girls/All Math, University of Nebraska; Canada/USA Mathcamp, Mathematics Foundation of America; PROMYS, Boston University; Ross Mathematics Program, Ohio State University; Stanford University Mathematics Camp; SWT Honors Summer Math Camp, Southwest Texas State University; and University of Chicago Young Scholars Program. All share the goal of bringing to young people the joy and satisfaction of mathematical exploration and discovery.

I first heard about these programs from mathematicians whose passion for mathematics had been kindled when they participated in such programs as teenagers. One of the best known of these is the Ross Mathematics Program, founded by the legendary Arnold Ross and run since Ross's death last year by his longtime colleague Daniel Shapiro. The Ross program has been especially influential and has served as a model for other successful programs. One of these, the SWT Math Camp, run by Max Warshauer, was recently profiled in the *New York Times* ("Bring on the Problems? It Must Be Math Camp", by Michael Winerip, July 30, 2003). As the *Times* article showed, these programs can have a profound effect on students' lives, opening horizons to them that they might not otherwise have dreamed of.

In the past several years I have gotten to know some of the dedicated people who direct and teach in these summer programs—people like Ross, Shapiro, Warshauer, and David Kelly, director of HCSSiM. These people love mathematics, and they know how to inspire that love in young people. "We want students to see themselves as creators of mathematics rather than learners of its results," Kelly remarks. This sometimes means that ideas and questions from students lead in directions the program instructors do not expect. Nevertheless, the enthusiasm of the students propels the discussions forward. "When you let students discover and formulate things for themselves, they pull you through the material much faster than you could drag them," Kelly says.

Kelly's soft-spoken manner belies an iron-willed commitment to students and to keeping the program alive. The survival of HCSSiM has been threatened many times by budget problems, but Kelly has managed to keep it going for all but one of the past thirty summers. As he puts it, "I love the program six weeks a year"—when the students are there—"and I hate it forty-six weeks a year"—during the annual grind of proposal writing and fundraising. The Epsilon Fund helps in a small but important way by providing grants that are low on red tape.

Kelly takes seriously the need to recruit female students. "We don't have as many women as we would like, but we have served them well," he says, pointing to such successful female alumnae as Susan Landau, a mathematician at Sun Microsystems. One 2003 participant, Mariah Kellam of Freeland, Maryland, wrote at the end of the program: "At my school, everyone thought I was crazy to do things like read Feynman lectures and math books in my free time, but now I realize that there are other people like that.…I have never been this happy or this happy for this long."

It is getting on to ten o'clock in the evening, and about a dozen HCSSiM students sit around tables in a classroom, discussing a set of problems in knot theory. "So prove it then," one student challenges another. He draws a diagram on a piece of paper and slides it across the table. "But it could be a circle," the other replies. "Oh yeah," the first student muses, realizing that the situation is more complicated than he initially thought. These students are learning one of the main lessons of HCSSiM: that mathematics is a living subject constantly renewed through communication with others. The work continues, the exchanges flowing freely as the students wrestle with the problems into the night.

Whether these kids go into mathematics or into some other field, they will take with them the experience of really *doing* mathematics. The Epsilon Fund is helping to ensure that mathematically talented young people have access to these experiences. It is a cause to celebrate and to support.

—Allyn Jackson

For information on the Epsilon Fund, visit the website `http://www.ams.org/development/epsilon.html`. Information about applying for Epsilon grants may be found at `http://www.ams.org/employment/epsilon.html`.

Letters to the Editor

Replies to Krantz

In his recent opinion piece "For Whom the Bell Tolls" (August 2003), Steven G. Krantz bemoans the plethora of career choices available to students who in our generation would have gone into mathematics. As always, Steve's piece is witty and thought provoking. But it does contain some rather extreme exaggerations.

Consider, for example, his second paragraph:

"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 pseudo-discourse."

Money-driven pseudodiscourse? Really? Let's see now, one of the great triumphs of 20th-century science was the discovery of the structure of DNA and the complete decipherment of the genetic code. But that's only half the problem. Living things, including mathematicians like Steve and me, carry out most of their regulatory functions through the use of *proteins* synthesized by DNA. Attempting to understand how proteins do this is what *proteomics* is all about. The people I know in proteomics think rigorously, if not mathematically; bring an enormous body of knowledge to bear on the problems they investigate; rigorously test their hypotheses in their labs; and maybe will help people like Steve and me live longer.

One could defend the other fields Steve mentions in the above quote, even computer science, but let's pass on to his fourth paragraph:

"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?"

Well, ever since George Babbitt and Willy Loman, marketers have been given a hard time, but let's consider gene cloning and chaos. Gene cloning is part of the ongoing revolution in biology, along with proteomics, bioinformatics, and genomics. When a neighbor down the street helped discover that the homeobox genes controlling development in fruitflies and mice were nearly identical, that said something very deep about the way multicellular animal life first organized itself and then evolved into the plethora of living creatures we see today. Maybe it's not mathematics, but it's good—very good. And as for chaos, one has to admit that its applications to nature certainly have been overhyped, but I hope Steve does not intend to trash *dynamical systems*. I think that's how we mathematicians study chaos.

But it's always great fun arguing with Steve, and other parts of his article are dead right, especially when he describes the "rapture" of mathematics and says:

"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."

Except for the slight "without parallel" exaggeration, who could disagree with this? RIGHT ON, Steve!

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In an editorial in the August issue, Steven Krantz attempts to enunciate a call to arms in the mathematics community for more and better graduate students and for greater passion from those students about becoming academic mathematicians. Actually, his argument makes a reasonably good case for why passionate students might well be *leaving* mathematics so as to avoid the kind of life that Krantz is championing.

My own degrees, including a Ph.D. in number theory, are all in mathematics. I am one of those whom Krantz denigrates. I left mathematics a year out of my doctorate, and I have never really returned. In 1977 I left a future of nomadic wandering in mathematics for a life in computer science. I left a world of serflike instructorships for one in which instructors have terminal master's degrees (and aspirations that match their abilities) and tenure-track positions are the norm. Finding a reasonable position was not a hopeless dream. And, yes, the pay is much better, but I see nothing wrong with that.

Yes, I miss the rigor and the clarity of mathematics and its arguments, but I have kept my hand in and continued to publish in mathematics from time to time. I abhor the goal-oriented nature of my students, who seem all too often to want only to become skilled rather than educated. I complain about the workload of graduate classes that start the term with 35 students. But I appreciate in computer science the vitality of a discipline that reinvents itself every three to five years, and I appreciate the bright vibrancy of my department. For all the headaches, overwork, and funding nightmares to keep equipment up to date, I wouldn't dream of going back to the gloomy corridors of any of the mathematics departments I've ever walked through.

What I find most satisfying of all is the solution of problems. I am not proving theorems whose purposes are, as was once told me in a mathematics class, to be able to prove more theorems. I am not (although some of my colleagues in computer science are) showing how one *might* compute something should one ever be forced to stoop to the level of actually computing something. I am *in fact* computing things and trying to tease the truth out of a real world reluctant to give up its secrets without a fight.

Perhaps I have always been a heretic. Without knowing it, perhaps I chose number theory because in number theory one can almost invariably find actual examples that illustrate the theory. This is probably antithetical to the monkish satisfaction with pure thought that Krantz would seem to be promoting, but it may explain why I have been able to make peace with the real world in a way that has apparently made me unfit to be "a real mathematician".

There is a joy about proving theorems that we need to impart to students. But there is also nothing the matter with applying mathematical concepts to problems in biology or data mining. As *The Double Helix* and *The Soul of a New Machine* both show, the joy of the hunt is not confined to academic mathematics. If the students who are passionate about what they do are voting with their feet to go into other disciplines, then perhaps the problem is not with the students, nor with their mentors, but with the discipline of academic mathematics as those mentors choose to define it.

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In "For Whom the Bell Tolls" (August 2003) Steven Krantz laments that today's graduate students are not passionate about pure mathematics: "Fifty years ago the student who had a proclivity for strict analytical thinking naturally gravitated to a career in mathematics.…Today the student with mathematical talent can consider a career in bioinformatics, genomics, proteomics, financial derivatives.…"

Krantz is indeed correct that students today have many options. However, just because a student leaves the department does not mean that she has left mathematics or that she will never again feel the "rapture" of problem solving.

The line between applied mathematics and science is artificial, and practicing our trade in other arenas enriches all of mathematics. The euphoria of pushing the limits of human understanding is not diminished by the lack of rigorous proof or the discipline of the problem.

In fact, many of us believe that what applied mathematics lacks in primitive beauty it makes up for in the miracle of abstracting reality.

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What's in a Name?

When college students fill out a questionnaire about a mathematics course they are taking, it's called "course evaluation". Regrettably, it is not really an evaluation of the course at all; it is just a student satisfaction survey pertaining to certain aspects of the course. When it is misused as *the* method of assessing our educational performance, there can be rather nasty consequences.

I know instructors (elsewhere) who are afraid to make even modest demands of their students for fear of low survey scores. Some fear that giving bad grades will do the same. I have even heard that in some universities, one's numerical scores on course surveys are put in as the teaching component of the formula for determining salary increments. Now what does that encourage? And, last but not least, junior faculty do worry, with good reason, that their careers might be jeopardized by bad survey scores. Is this our model of education? The possibility of blind use of the surveys encourages us to ask less of our students.

At a more fundamental level, there is widespread dissatisfaction over the inadequate learning of calculus by undergraduates. The serious educator asks: Is there anything we can *do* to raise their level of performance? The ideal answer: Change the attitude toward their education that too many students bring to college. Cynics would say, "Don't waste your time." Most would say naively, "Explain the material better." Even when a course is run under a fixed syllabus, there is a wide range of options for the level of aspirations. Thus, what constitutes *the material* is a variable. Slower (fewer) explanations by an instructor will be easier to follow, so perceived as better ones; this chips away at the material to be learned outside the classroom and therefore in the course. In other words, we do have a serious choice to make.

In my experience, when aspirations are fixed, notably when service courses involve several instructors and common exams, there is little difference among the mean achievement levels of the students of each instructor. The students may say in the survey that one instructor explains things much better than another, but that does not show in performance on the exams. What, then, *is* the true role of the instructor? To do something that improves learning. But that might lower survey scores.…

A department chair once felt I was trying too much to improve student attitudes. He suggested I do like a popular instructor who gives "brilliant explanations" [and gets high survey scores]. An exchange ensued. "Does he get results?" That took my chair by surprise. "What do you mean?" he hastily asked. "Are his students *learning* better?" [evidence says no]. "I don't know. How would one measure that?" I thought a little. "You might look at the exams to assess their difficulty, determine what the students knew in advance about them, and then look at the scores."

Is it possible to determine the learning engendered by the instructor by polling the students? I'd be shocked if it were. After all, students have no frame of reference; they can only gauge their impressions in comparison to the aspirations of the instructor with whom they took the course. A consultant on course evaluation (J. Franklin) gave me a resounding "no" when I asked her. Examples from my own department say likewise.

In sum, when we give the surveys, we seek something easy to implement, ask for some useful feedback. It is incomplete and at bottom of secondary importance. Then we fail to remember that's all we did. *With nothing else put forth to comprise a serious evaluation, people end up pointing to the surveys as the neutral assessment of the instructor.* For example, the mandatory letters on teaching for applicants for junior positions tend to cite survey numbers as evidence of teaching ability; their omission often leads to a negative inference. I wonder, then, how many mathematics departments go beyond the surveys for the education component of personnel decisions?

We can do better than that! We should feel free, to a reasonable extent, to push our students to succeed, without succumbing to de facto intimidation. With a serious assessment of learning in place, we would have a truer way of evaluating the course… and the instructor.

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Preparing Future Faculty

In the August 2003 issue of the *Notices*, Hyman Bass's essay on the Carnegie Initiative on the Doctorate (CID) concluded that "the traditional doctorate in mathematics has been fashioned almost exclusively on a disciplinary view of the field." The author further argued for an expansion of this model "to encompass the modern evolution of mathematics as a profession."

The essay laid out in some detail several examples of what such expansion should include in practice.

We are writing to point to the Preparing Future Faculty Program (PFF, http://www.preparing-faculty.org). PFF was launched in 1993 as a partnership between the Council of Graduate Schools (CGS) and the Association of American Colleges and Universities (AAC&U). In the 1990s it developed comprehensive, university-wide model programs that address many of the issues championed by CID and in Hyman Bass's essay. In addition to seminars and workshops that address a broad range of professional roles and responsibilities, an integral part are visits at a variety of different kinds of universities and colleges. Typically these are followed up by multiday projects in which students get immersed into the different cultures.

Starting in 1998, the PFF program began, with support of the National Science Foundation (NSF) and in collaboration with disciplinary associations, to develop discipline-specific PFF programs. In mathematics the AMS and the Mathematical Association of America (MAA) requested proposals (http://www.ams.org/government/PFF-RFP.html) and initially funded four proposals to develop models for PFF programs in mathematics (PFMF). Visit (the "PFMF Archive" of) http://math.asu.edu/pff.html to see such a typical implementation and to find links to other PFMF institutions.

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The Mathematics Doctorate: Can We Change?

The recent article "The Mathematics Doctorate: A Time for Change" (September 2003) by Tony F. Chan was an excellent analysis of the problems facing mathematics Ph.D. programs. In the early part of the article he states that the mathematics community has produced over the last two decades many national self-studies urging fundamental changes. But based on the persistence and recurrence of the issues presented in those studies, he concludes that very little change has been made.

Chan is correct, and unfortunately his own article will likely fall into that same pile of glossed-over studies, not because of flawed analysis, but because like the others it fails to get to the deeply underlying view of mathematics held by its practitioners. Many of his suggestions for change hint of the "big science", entrepreneurial, team approach to research and education much admired by university administrators and magnificently exemplified by engineering, medicine, and the laboratory sciences. And magnificently supported, in our view (but not theirs!).

But mathematicians have as their Holy Grail the finding and proving of a *theorem*, and the pursuit of that goal is usually accomplished alone or possibly with one or two fellow seekers. Look at our eminent heroes of the past and present, our Fields Medalists, and our National Academy members. Then look at the top senior mathematics professors at doctoral-granting universities. For the vast majority, all their study and energy is dedicated to the *theorem*, and by the nature of graduate **emulation**, not graduate education, universities will produce new acolytes each year.

Certainly we are pleased and make much hullabaloo when a *theorem* turns out to create a major steppingstone in the engineering or scientific enterprise. But our usual inclination after the fuss is over is to improve the result, consider more general interpretations, and move into more abstract realms, often far removed from the original problem. This is the nature of our training and our view of what is mathematical success, whether in pure or applied mathematics, and this is our legacy to our graduate students.

Our work ethic is a scholarly one—some might even say a medieval one—more akin to philosophy than to high-energy physics or mechanical engineering. When we say, "I have to get back to work," we are not likely planning to rush off to organize study teams, create new experiments, join a task force, or write new grant proposals. It usually means we are returning to our office, closing the door, happily pulling out the pen and yellow legal pad, and possibly turning on the computer in search of the *theorem*.

It is this culture, described in part above, that must be accounted for when we read reports like Chan's strongly advocating change. The culture is our real strength, yet will often be a subtle, unstated barrier to acceptance of broad recommendations. We should not try to change it in the quest for more funding, but must incorporate it into our presentations on how to improve our graduate training. Now read Chan's article again!

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