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FOCUS

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On the cover: Frank Farris, who created our cover image, describes it as follows: "the cover image is a domain coloring map for a sixth degree polynomial. In this diagram, the values of this polynomial are represented by color: zero is white, infinity is black, and hue represents argument. A sixth degree polynomial should have six zeroes, but one is a double zero, as you can detect from the arguments around it. I call this one Van Gogh, because this fellow's ear is about to come off!"

FOCUS Deadlines

	August/September	October	November
Editorial Copy	July 13	July 27	September 15
Display Ads	July 27	August 20	October 6
Employment Ads	July 20	August 17	September 22

United States to host 42nd International Mathematical Olympiad in July

Beginning on July 1, and running until July 14, the 42nd International Mathematical Olympiad – the grandest high school mathematics competition in the world – will be held in Washington, D.C., and at George Mason University, in Fairfax, Virginia. It will bring together 500 of the world's most talented high school mathematicians, from more than 80 countries. "The United States," said John Kenelly, President of IMO 2001, the "can take pride that we are hosting the premiere international event for math students." The highly competitive event is being hosted and organized by the MAA. Its sponsors are the U.S. Department of Energy, the National Science Foundation, the National Security Agency, the Texas Instruments Company, and Wolfram Research, Inc.

The theme of the 2001 IMO is "Mathematics Expands Horizons." The American mathematics community will use this grand opportunity to promote the importance of mathematics and to celebrate the accomplishments not only of its best and brightest students but of all mathematics students.

During the IMO competition, competitors will work individually over a two-day period on six challenging problems, and will present their solutions as essay-style proofs akin to those that research mathematicians produce. Grading of the answers takes several days. During this period, the IMO students will be treated to American hospitality and culture by visiting attractions in and around the Capitol and experiencing American life and its diverse culture. The event will culminate with the fireworks on the Mall of the U.S. Capitol on July 4.

The US Team

The US team was selected through a series of three examinations held this spring by American Mathematics Competitions (a program of the MAA) and sponsored by 13 mathematical organizations. The first exam was taken by more than 350,000 students. The tests culminate with the USA Mathematical Olympiad, involving about 180 students from across the country. To demonstrate their mathematical knowledge, students worked on six complex pre-calculus problems requiring insight and ingenuity. The six students with the best performance were selected to represent the United States at this year's IMO gathering in the nation's capital.

Record of Performance

The US has a history of success in the IMO, having scored among the top five teams in 21 of the 24 years in which it has participated. Excellent individual performances have earned 148 of the 156 team members Gold, Silver or Bronze medals. Most outstanding was the unprecedented perfect score by every member of the US team at the 1994 IMO, which was held in Hong Kong. The IMO's presence in the US this year will, therefore, make clear that the very best of our young people are as mathematically talented as any in the world.

Many past USA team members have begun distinguished academic careers, while many others are now doing research for leading institutions such as IBM, Los Alamos, Brookhaven, JPL, Bell Laboratories, and Wolfram Research. Others have used their exceptional mathematical talents in the service of the nation at agencies such as the National Security Agency. Several are pursuing careers in law and medicine, while still others make contributions to the financial world and Wall Street.

Research and Outreach

The IMO will provide an opportunity to implement a research project directed to learning more about young people with exceptional talent, by investigating differences among countries to provide new insights into the education of US students and to find better ways to identify and nurture young talent in this country.

The IMO was last held in the United States in 1981. One goal of this year's IMO is to use the occasion of the return of the IMO to the US as an occasion to enhance public understanding of and appreciation for mathematics. In the last few months leading up to the IMO, large numbers of students and members of the public have been engaged in mathematical activities that advance mathematics for all in the US. ■

MAA Selects Robert Witte as Leitzel Lecturer

Robert F. Witte, the former ExxonMobil Foundation senior program officer for Project NExT as well as ARUME, has been selected as the MAA's James R. C. Leitzel Lecturer for MathFest 2001. The gathering of mathematicians will take place in Madison, Wisconsin, this summer. Witte will be the first nonmathematician to give the prestigious lecture, which was named for longtime MAA member James R. C. Leitzel who served the Association in numerous capacities until his death.

A member of the board of the National Alliance of State Science and Mathematics Coalitions, Witte's selection was confirmed by the MAA Board of Governors last January. He holds a B.S. in Mechanical Engineering from Iowa State University and a Masters in Business Administration from Harvard. Witte joined the Exxon Corporation in 1960, and in the late-1970s he took up responsibilities in the company's Public Affairs Department, incluing the management of corporate contributions programs, policy analysis and planning, and liaison with public policy research groups and educational institutions.

Witte began his involvement with the ExxonMobil Foundation, which was founded in 1955 as the company's primary vehicle for philanthropy, as a program officer in 1992. Its grants and other contributions have helped support the MAA's Project NExT and the Association for Research in Undergraduate Mathematics Education (ARUME). ■

The Latest on Catalan's Conjecture

by Andrew Granville

If one writes the sequence of squares, cubes and higher powers of integers in increasing order

$$1, 4, 8, 9, 16, 25, 27, 32, 36, 49, 64, 81, 100...,$$

one notices that they become increasingly sparse. As far out as one could conceivably compute one finds that the smallest gaps between consecutive powers become larger and larger, and indeed 8 and 9 seem to be the only consecutive integers in this sequence. In a letter to *Crelle's* Journal in 1844, Catalan noticed this and wrote "I believe that this is true, though I have not yet given a complete proof; others perhaps will be more lucky." A precise statement of what is now known as **Catalan's conjecture** goes as follows:

The only solution to

$$X^m - Y^n = 1 \qquad (1)$$

in integers $X, Y, m, n \geq 2$ *is* $3^2 - 2^3 = 1$.

To this day Catalan's conjecture remains unproved, though, as I shall report in this article, researchers are coming tantalizingly close to showing that Catalan was indeed correct.

To begin with, note that if there is a solution to the above equation where a prime p divides m and prime q divides n, then

$$x^p - y^q = 1 \qquad (1')$$

with $x = X^{m/p}$ and $y = Y^{n/q}$. Thus, Catalan's conjecture can be re-phrased as stating that there are no solutions to (1') in integers $x, y > 1$ and primes p and q. With this observation in hand let us begin by surveying the key results known before the most recent attacks on this famous problem:

The first recorded result on Catalan's conjecture came over five hundred years before Catalan's letter: Levi ben Gerson (1288-1344) showed that the only powers of 2 and 3 that differ by 1 are $3^2 - 2^3 = 1$ (note that we don't mention any of the solutions $2^2 - 3^1 = 3^1 - 2^1 = 2^1 - 3^0 = 1$ since in each case at least one of the exponents is less than 2). Roughly a hundred years before Catalan's letter, Euler in 1738 showed that the only square and cube (of rational numbers) that differ by 1 are $3^2 - 2^3 = 1$.

In 1850, Lebesgue showed that there are no solutions when $q = 2$ in (1'), and in 1964 Chao Ko showed that there are no solutions when $p = 2$ in (1'), except of course $3^2 - 2^3 = 1$. In 1921, Nagell showed that there are no solutions in (1') when $p = 3$ or $q = 3$ (except the ubiquitous $3^2 - 2^3 = 1$).

Therefore we can now assume that $p, q \geq 5$. By 1961 Cassels had shown that for any solution in (1') we have that p divides y, and q divides x, so that we can write where a, b, u and v are integers for which $(pa,u) = (qb,v) = 1$, with $x = qbv$ and $y = pau$.

$$x - 1 = p^{q-1}a^q \text{ and } \frac{x^p - 1}{x - 1} = pu^q$$

$$y + 1 = q^{p-1}b^p \text{ and } \frac{y^q + 1}{y + 1} = qv^p$$

In 1929, Siegel showed that any curve of positive genus has only finitely many integer points: In our example this means that if we fix primes $p, q \geq 2$ then there are only finitely many integers x and y satisfying (1'). Unfortunately Siegel's proof does not give us any hint how to restrict the possible values of x and y in such a way that we can mount a search and find all solutions. It was not until the 1960s with Baker's Fields medal winning work on linear forms in logarithms that it became possible to bound the sizes of x and y in terms of p and q, though the bounds that come directly out of his technique were so large as to be uncomputable in practice. Nonetheless it was Baker's work that heralded the more recent assaults on Catalan's conjecture, and indeed in 1976 Tijdeman, using Baker's Theorem, showed that x^p (and so y^q) are bounded by some computable absolute constant in any solution of (1'). A succession of authors computed such a constant, trying to make it so small that all examples in (1') might then be found by a practical computer search.

Preda Mihăilescu next to a Klein bottle sculpture at Oberwolfach

The latest upper bounds are (according to Mignotte) $\min\{p,q\} < 7.15 \times 10^{11}$ and $\max\{p, q\} \leq \max\{m, n\} < 7.78 \times 10^{16}$ – as we shall see later, upper bounds on x and y are unlikely to be important in the eventual resolution of Catalan's conjecture so we will not write them out, though in principle they could be written out.

Fermat's Last Theorem and Catalan's Equation

Wiles, of course, recently proved Fermat's Last Theorem, that there are no positive integers x,y,z and prime $p > 2$ for which

$$x^p + y^p = z^p. \qquad (2)$$

There is much in common between these two famous problems, and indeed several of the techniques used on Fermat's Last Theorem, over the three and a half centuries in which it was an unsolved problem, can be adapted to Catalan's Conjecture. Most important pre-Wiles results on Fermat's Last Theorem involved an in-depth understanding of the arithmetic of the pth cyclotomic field, that is the field generated by the rational numbers and the pth roots of unity (this is because $x^p + y^p$ factors into linear factors in this field). One famous such result on (2), by Kummer in the middle of the nineteenth century, is that if p does not divide the class number of the pth cyclotomic field then there are no solutions to (2). Another, by Wieferich in 1910, that unless $2^{p-1} \equiv 1 \pmod{p^2}$, then p divides xyz in any solution to (2). Note that although $2^{p-1} \equiv 1 \pmod{p}$ for every odd prime p, it is very rare that this congruence holds (mod p^2); indeed for primes $p < 2^{32}$ it only holds for $p = 1093$ and $p = 3511$. Subsequent authors showed that the '2' in $2^{p-1} \equiv 1 \pmod{p^2}$ can be replaced by '3', '5' or any odd prime up to '109' (and feasibly beyond, though to prove such a result for $q^{p-1} \equiv 1 \pmod{p^2}$ for any given prime q seems to require a prohibitively lengthy computation when q is large).

Since $x^p - 1$ also factors in the pth cyclotomic field, and $y^q + 1$ factors in the qth cyclotomic field, one might guess that analogous results could be proven for (1'). In 1964 Inkeri figured out how to do this, obtaining criteria involving class numbers and "Wieferich-type congruences". In the last decade there have been several papers trying to simplify Inkeri's results (and approach). Ultimately, though, it was an amateur mathematician, Preda Mihăilescu, who works for a fingerprinting company in Switzerland, who put Inkeri's idea into perhaps its ultimate form. In a paper just accepted by the *Journal of Number Theory*, he shows that if there is a solution to (1') then $p^{q-1} \equiv 1 \pmod{q^2}$ and $q^{p-1} \equiv 1 \pmod{p^2}$.

Grantham and Wheeler have computed the only such "Wieferich pairs" with $3 < p,q < 3 \times 10^8$: there are a few, such as (5,1645333507), (83, 4871), (2903, 18787) and (911, 318917), but we expect very few overall. (Mihăilescu also showed that q^2 divides x and p^2 divides y, improving on Cassels). By rather different considerations, Bugeaud and Hanrot (adapting ideas of Bilu and Hanrot) show that if there is a solution to (1') and

$$q > \frac{p}{2}\cdot\left(1+\frac{1}{\log q}\right)$$

then q divides $h^-(p)$, the "relative class number" of the pth cyclotomic field: This is easier to compute than the actual class number, and none of the Wieferich pairs listed above satisfy this criteria. Thus we know that in any unknown solution to (1'), p and q are both greater than three hundred million.

Therefore we now know that $p, q > 3 \times 10^8$ and $m, n < 7.78 \times 10^{16}$, so that $m < p^2$ and $n < q^2$. That means that $m = p$ and $n = q$; that is, in any solution to (1), m and n must both be prime! In any unknown solution to (1') we now have $3 \times 10^8 < \min\{p,q\} < 7.15 \times 10^{11}$ and $\min\{p,q\} < \max\{p, q\} < 7.78 \times 10^{16}$. This range seems to be close to what might be feasible computationally. A fairly straightforward algorithm could check all the remaining pairs in something like 10^{30} steps, not too far beyond what is practical, but far enough that one expects additional ideas will be needed before a final computer onslaught will be successful.

The Fermat-Catalan equation

With the solution of Fermat's Last Theorem, and perhaps of Catalan's Conjecture in the very near future, we might ask what is the next big question of this flavor. My own personal favorite is

The Fermat-Catalan Conjecture: *There are only finitely many triples of coprime integer powers x^p, y^q, z^r, for which*
This generalizes both (1') and (2). From

$$x^p + y^q = z^r \text{ with } \frac{1}{p}+\frac{1}{q}+\frac{1}{r} \le 1. \quad (3)$$

"classical" results we know that the only solution when $1/p + 1/q + 1/r = 1$ is $1^6 + 2^3 = 3^2$. There are ten solutions (x, y, z) known to the above equation:

$$1 + 2^3 = 3^2, 2^5 + 7^2 = 3^4, 7^3 + 1^{32} = 2^9,$$
$$2^7 + 17^3 = 71^2, 3^5 + 11^4 = 122^2,$$
$$17^7 + 76271^3 = 21063928^2,$$
$$1414^3 + 2213459^2 = 65^7,$$
$$9262^3 + 15312283^2 = 113^7,$$
$$43^8 + 96222^3 = 30042907^2,$$
$$33^8 + 1549034^2 = 15613^3.$$

Perhaps these are all. Noting that all of these solutions involve an exponent '2', might lead one to conjecture that there are no solutions to $x^p + y^q = z^r$ in coprime integers x, y, z when p, q, r are all >2. This conjecture was made by Dallas banker Andrew Beal, who subsequently offered a substantial cash reward ($50,000) for its resolution!

Darmon and I have shown that for any fixed such p, q, r there are only finitely many solutions to (3), as a consequence of a deep theorem of Faltings. Important cases for which the conjecture is known to be true are: $p = q = r$ (Wiles), $p = q$ and $r = 2$ or 3, as well as $p = r = 4$ (Darmon and Merel), $p = q = 3$ (Kraus), $(p,q,r) = (2,4,5)$, $(2,4,6)$ and $(2,3,8)$ (Bruin), all using interesting, deep ideas. Darmon has outlined a program to modify Wiles' approach to Fermat's Last Theorem, to prove the Fermat-Catalan Conjecture. His ambitious ideas, though impractical at the moment, boldly set a direction for future attacks on such problems.

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Andrew Granville is professor of Mathematics at the University of Georgia at Athens.

Akamai Foundation Signs Agreement with the MAA to Sponsor Major Mathematics Competitions

Seeking to play a long-term role in the advancement of mathematics education nationwide, and even globally, the Akamai Foundation of Cambridge, MA, has signed an agreement with the MAA for the mutual benefit of both organizations. One of the key elements of the agreement allows the foundation to become the sole corporate sponsor of the American Mathematics Competition, the USAMO, and other related MAA programs in the next year. In return, Akamai will provide the MAA $600,000 to support these activities and has the right to extend the agreement in the future.

In order to sponsor and market the above mentioned mathematics competitions and help develop mathematics education programs that reach a wider audience, Akamai is, among other things, developing its "Magic of Math" web site, which is filled with mathematics games, offers homework help, and has a chat room. Eventually, the site – Akamai.com – will offer AMC/USAMO content and offer information, registration, and teacher/parent/student resources in mathematics. And to help the foundation attain its ends, the MAA will offer advice and expertise to Akamai.

The funding from Akamai is to be used to enhance and extend the MAA's AMC/USAMO programs with a goal of recruiting, recognizing, and rewarding a larger and more diverse group of students. The new activities to be supported include a scholarship program for this year and the next, and for next year's USAMO, and an extended summer program for all freshman, sophomore, and juniors who take the USAMO.

The scholarship program will recognize the top three winners of the USAMO as well as the top female and male scorers on AIME in each state, in Washington, D.C., and in U.S. territories. In addition, students who score the highest on the USAMO and who participate in the IMO will be rewarded with college scholarships: $15,000 for first place, $10,000 for second, and $5000 for third. Students who take the USAMO and are in ninth through eleventh grades will be invited to the Mathematical Olympiad Summer Program in an expanded format; the MAA hopes to see a diversity of outstanding students recognized and rewarded for their achievements. In addition, teachers/coaches from underrepresented areas (inner city, Appalachia, Native American schools, etc.) will be invited to the summer program and assisted in implementing the AMC program at their schools; their top students will be invited back to the next summer program.

Dr. Stephen Dunbar, Professor of Mathematics and Computer Science at the University of Nebraska, will serve as the MAA's Special Assistant for Pre-college Outreach. He will oversee AMC/USAMO operations, particularly the Akamai funded initiatives; he will work to associate the AMC program with other middle and secondary school competitions. ■

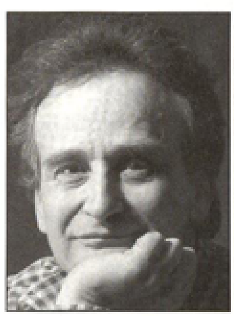
Arnold and Shelah Will Share 2001 Wolf Prize

The Wolf Foundation has announced that Vladimir I. Arnold of the Steklov Mathematical Institute in Moscow and Saharon Shelah of the Hebrew University in Jerusalem will share the 2001 Wolf Prize in Mathematics. The prizes will be conferred at a special ceremony at the Knesset in Jerusalem, on May 13.

Vladimir I. Arnold

The citation praises Arnold "for his deep and influential work in a multitude of areas of mathematics, including dynamical systems, differential equations, and singularity theory." It also notes that Arnold's work has "had a profound influence on an entire generation of mathematicians." Arnold is a Professor at the Steklov Mathematical Institute in Moscow, Russia, and also holds positions at Moscow University and at the University of Paris-Dauphine.

Shelah is cited by the Foundation for "his many fundamental contributions to mathematical logic and set theory, and their applications within other parts of mathematics." They describe his work as including "the creation of several entirely new theories that have changed the course of model theory and modern set theory." Shelah has been Professor at the Hebrew University of Jerusalem since 1971.



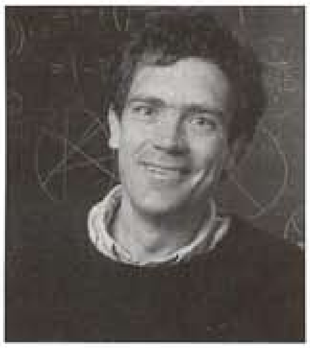
Saharon Shelah

The Wolf Foundation was established by the late German-born inventor, diplomat and philanthropist, Dr. Ricardo Wolf. A resident of Cuba for many years, Wolf became the Cuban ambassador to Israel, where he lived until his death in 1981. Five annual Wolf Prizes have been awarded since 1978 to outstanding scientists and artists. ■

Formulating a Plan for Your Professional Future

At the Joint Mathematics Meetings in January, the 1994–1996 Project NExT Fellows organized a panel to address some of the needs of faculty who, while no longer "new" in their positions, are not yet fully established. It was directed at mathematicians who have been in the profession for four to ten years, and it was open to all participants in the Joint Mathematics Meetings. The discussion centered on such issues as balancing the roles of teaching, scholarship, and service in professional life, planning a sabbatical and using it well, finding ways to invigorate one's research in new fields (in academia or industry), taking administrative roles inside and outside one's institution, undergoing evaluative reviews, and changing jobs after getting tenure.

Rick Cleary: Consulting and Administration



Rick Cleary

On consulting: think broadly. One can find consulting work that serves the greater community. Opportunities often arise from students doing internships; for example, a group of mathematics graduate students at a regional meeting were complaining about a lack of funding for summer teaching at their home institutions. When an applied mathematician sitting with them suggested that they take a class in finance and then work as consultants, they seemed to feel this was too far from their experience. There is a perception among pure mathematicians that we are unprepared, but this is not necessarily the case! In general, you are worth more than you think (the minimum hourly fee should probably be $100.00).

Administration is a tremendous responsibility, and this is the hardest part of the job. However, someone must make the difficult decisions, and as the effects of bad administration are far-reaching it is critical to have good people in these positions. Administration is also very rewarding and one can take pride in the work. Finally, doing administrative work can help avoid any 'burn-out' associated with teaching a similar array of courses every year.

Anant Godbole: Using sabbaticals, and the symbiotic relationship between one's own and undergraduate research

With regard to sabbaticals, there is one word of advice: GO!!! The typical sabbatical from many schools is a half-year at full salary or a full year at half salary, available once every seven years. Be sure to exploit every mechanism available at your institution, and try to negotiate creative solutions. For example, my department chair was willing to allow me to go on leave for a semester and make up the missed teaching over two years.

Go to a university where you know someone, perhaps the colleagues of your advisor or your "grand-advisor;" do not go back to the institution where you did your graduate work. Keep in mind that the institution you visit might be willing to pay you to teach a class or two (and also that statistics and operations research departments tend to pay more). It is often possible to go to the best mathematics departments in the country, and an invitation from an elite institution can help secure funding from your home institution.

Shifting to teaching issues, once a faculty member has tenure she or he can afford to not have stellar teaching evaluations each and every term, and this provides an opportunity to take risks with teaching.

Anant Godbole

In particular, I now try to include a research component in every course. The students are responsible for conducting the research, writing it up, and talking about it. Ideas for student research projects can come from many sources, perhaps from attending a talk and hearing something that strikes you as interesting. Open-ended questions and problems often work best, and the results need not be earth-shattering. Furthermore, seemingly small results can often lead to other things. Being involved with undergraduate research can also broaden your own research interests in surprising and unforeseen ways; for example I became interested in combinatorics after directing student projects in that area.

One example of a problem which could be used as the focus of an undergraduate research project involves the Kaprekar Number. This problem is named after the Indian mathematician D.R. Kaprekar who discovered it in the mid-twentieth century. Start with any four-digit number with different digits. Then, rearrange the digits so that the largest and smallest numbers are formed. Subtract the latter from the former to obtain another four-digit number. Repeat the process and eventually (in seven or fewer steps) the Kaprekar number 6174 will be obtained as the end result. There are many other problems like this one that can be considered as topics for student research projects.

Formulating a Plan for Your Professional Future, continued

Patti Frazer Lock

Patti Frazer Lock: Issues affecting professional and personal life

One of the challenges we face in the pre-tenure/early post-tenure career stage is balancing personal and professional lives, often including the infamous two-body problem. In particular I was pregnant during the first, third and fifth years on the job, and nursing through the second, fourth and sixth years, before being tenured in the seventh year!

Another challenge is balancing teaching, scholarship and service. I still find it difficult to accomplish significant amounts of scholarship in the school year, but concentrating research efforts in the summer has proven successful.

Being open to change can revitalize your research. My research has changed directions, in both planned and unplanned ways. After writing a dissertation in quantum logics, I made a planned move after a few years to graph theory. Reading plenty of journals and finding a somewhat obscure topic to study initially contributed to the success of the move. Working with undergraduates could also facilitate making such a shift. Unexpectedly, I became involved in the Harvard calculus project and this has been very rewarding.

Donna Molinek: Teaching, Scholarship and Service in the newly post-tenure years

On the topic of getting tenure: it is important to find your niche and be tenured on the basis of who you really are. As Anant Godbole mentioned, tenure provides an opportunity to experiment more in teaching.

Scholarship changes in the early post-tenure years, as the newness is gone and the thesis is gone. Traveling to conferences (regardless of funding), teaching topics courses outside your area of expertise, and preparing undergraduate colloquium talks can all lead to revitalization. By all means, take a full year sabbatical!

Donna Molinek

As a newly-tenured faculty member, you may find you are now asked to do many things in the service arena, by both the university and the broader community. For example, I was asked to serve on a church finance committee, and became involved with a "math superstars" program at a local school. Getting involved in these activities and positions within the university can open doors to other opportunities, and may be rewarded in your department. Use care when taking on these roles; it can be difficult to say no. Again, it is critical to find your own niche.

Questions and Answers:

Do you have any advice about applying for tenure? What about post-tenure review?

One problem is that we tend not to write down what we do. Write everything down! E-mailing yourself is a good way to do this, as is keeping a list of the ten best things you've done in a given year. Think in terms of having a shoebox full of receipts, in case you're ever audited. Also, be sure any persons writing letters for you have plenty of information; factual errors in letters are bad (RC). You're probably already doing most of what you need to; tenure can be viewed as determining whether or not there is a good "fit" instead of solely as an evaluative process (DM). Just do your job and keep a merit file. Also, write a draft for your tenure application and get feedback from outside the department as early as possible. Be honest about strengths and weaknesses (PL). Another suggestion is to read the description of the faculty ranks in the faculty handbook for guidelines.

What about administration, and what if you want to say no?

It is possible to say no. I was asked to consider several administrative positions and said no. Rotating positions are good as they provide an opportunity to try administration without committing yourself for life (PL). There is an administrative pull. I first served on a search committee, then as graduate director – these don't necessarily seem like "administration" but they are (AG, currently chair). If you want to say no, try saying "no for now" (PL). Ask for an interim appointment to try it out. This can give you leverage, which doesn't come often in a career (RC).

Do you have any advice on changing jobs after tenure?

Don't let tenure become a ball-and-chain. Leaving your institution can be a good career move, but don't decide lightly and be sure to have a plan worked out (RC). Moving can open up opportunities (PL). Becoming tenured the second time should be easier (AG).

My university is being bought out, and I may find myself suddenly without tenure. What should I do?

Explain the situation in your cover letter when you apply for jobs (PL).

Did you experience any post-tenure guilt and/or letdown?

No. (all panelists agreed)

Do you have any advice for developing consulting work outside of operations research or statistics?

Develop your niche, though this may not be easy. Sometimes a math department will get a phone call from someone with a question to be answered, and that can lead to something (one example: a forensic science case) (RC).

Any advice for dealing with a difficult/hostile department?

Lay low for the first few years of your career, but then stand up for yourself and do not be a doormat. Continue to be nice and collegial, even to those who treat you poorly. If necessary, talk to your dean or associate dean in a non-confrontational way (PL). It might be possible to ask why in a memo. Chairs and deans are required to respond to these (AG).

Do each of you have a "plan", and does it matter? Do you set goals?

In the past it was more "sink or swim", and I wasn't aware of the options. These days, there is more discussion about these issues. A saying goes "Life is what happens when you're making other plans." For example, I never foresaw my interest in graph theory and combinatorics (I wanted to "live in a Banach space!"), or that undergraduate research would become a defining activity for me (AG). I had a research plan, but it is hard to know what will happen. One can keep a year-long to-do list, written immediately after last year's activity report; this helps maintain focus (DM). I planned to be the best teacher I could, and have a fulfilling family. After tenure, more things open up. Be visible and great opportunities will come (PL). Things happen. I think I have a plan, but other things often come along. In the last few years, things in my career have happened so quickly that I haven't had time to make a plan. It may be better to think in terms of "direction" instead of "plan." It is great to have a plan, but be flexible and set your plan in "mushy concrete" (RC).

This panel discussion was held at the Joint Mathematics Meetings in New Orleans, January 12, 2001. The co-organizers of the session were George Ashline of St. Michael's College, Jeremy Case of Taylor University, and Cynthia Woodburn of Pittsburgh State University. The scribe for the session was Kim Pearson of Valparaiso University. The panelists were Rick Cleary, Senior Lecturer and Associate Dean for Undergraduate Programs at Cornell University, Anant Godbole, Professor and Chair of Mathematics at East Tennessee State University, Patti Frazer Lock, Professor of Mathematics at St. Lawrence University, and Donna Molinek, Associate Professor of Mathematics at Davidson College.

Read This! Recently Reviewed on MAA Online

The MAA Online book review column is still going strong. We now have over 200 book reviews and brief notices online. The latest reviews are featured at the main *Read This!* page at http://www.maa.org/reviews/reviews.html.

Recently reviewed books include:

Mathematical Puzzle Tales, by Martin Gardner

Stephen Smale: The Mathematician Who Broke the Dimension Barrier, by Steve Batterson

The Prime Numbers and Their Distribution, by Gérald Tenenbaum and Michel Mendès-France

Understanding Analysis, by Stephen Abbott

Teaching Statistics: Resources for Undergraduate Instructors, ed. by Thomas Moore

Einstein in Love, by Dennis Overbye

Number, from Ahmes to Cantor, by Midhat Gazalé

Mathematical Conversations: Selections from The Mathematical Intelligencer, compiled by Robin Wilson and Jeremy Gray

Mathematical Olympiad Challenges, by Titu Andreescu and Razvan Gelca

A Course in Computational Number Theory, by David Bressoud and Stan Wagon

Evaluating Derivatives, by Andreas Griewank

Essays on Numbers and Figures, by V. V. Prasolov

An Introduction to Game-Theoretic Modelling, by Michael Mesterton-Gibbons

Notes on "Balancing Career and Family"

by Heather Ames Lewis

The Young Mathematicians Network sponsored a panel on "Balancing Career and Family" at the Joint Mathematics Meetings in New Orleans in January 2001. The panel was organized and moderated by John Kuchenbrod (Emory and Henry College) and Heather Ames Lewis (Nazareth College). Our panelists were Cheri Boyd (Nazareth College), Stephanie Edwards (Bemidji State University), Patti Frazer Lock (St. Lawrence University), and Michael Prophet (University of Northern Iowa). The four panelists were all married; one had one child and two had three children. All were tenured or in tenure-track jobs, with careers ranging from two to twenty years.

After introductions, the moderators and audience members posed questions to the panel. What follows is a summary of each of the questions and the answers or suggestions that the panelists (and sometimes the audience) provided.

When you were looking for work, how did you handle personal questions or situations?

For a first job search, the panelists generally waited to mention a spouse until after some contact with the school, either during an interview or after a job offer. When changing jobs, however, people were more direct and mentioned it as early as in the cover letter. In general, if a couple only wants tenure-track jobs at the same school (or has some other such restriction), it is best to be up front and say that as early as possible.

The panelists pointed out several things to look for when "scouting out" a job or area. Is the department or school friendly? Do the faculty socialize together outside of school? How are course assignments and schedules developed (will there be flexibility)? Are there "cultural" expectations such as being in your office all day? (You can phrase this as a question about workload.) What are the local schools like? How is the local economy? Finally, several panelists encouraged finding out about benefits. Is there a packet of printed information that you can take with you? What are the health benefits and leave options? Can family members take classes for free (perhaps to pursue a degree themselves)?

What are the formal and informal policies on leave at your institution?

The formal leave policies at the different institutions were typically 6-8 weeks, usually paid; some schools offered a full semester of unpaid leave. The panelists and audience members provided several other possibilities for arranging a leave. Look at your health plan and benefits to find out exactly what the school guarantees. You might be able to make individual arrangements with the vice-president or dean for a longer leave (this might be paid, but will probably affect your tenure clock). You might be able to teach some of your classes in the summer and have a lighter load during the semester. If you have an allotment of sick days, you might be able to use them as a paid leave. Finally, you might be able to make arrangements within your department, having others cover your classes in return for your covering theirs at another time.

Have you been able to arrange your own teaching times?

All of the schools offered some flexibility in scheduling. Patti, for example, teaches Tuesdays and Thursdays (to complement her husband's MWF teaching schedule) and in return she is willing to teach absolutely any class. Similarly, Cheri often teaches in the morning while her husband works in the late afternoon and evening. Several people had rearranged traditional course offerings; for example, taking a class that's always been taught three days a week and offering it over two days, possibly starting earlier in the morning to avoid conflicts.

Some people tried to come home early and then work at home (grading, email). Others tried to keep their work at school, with time at home reserved for family.

There were many other suggestions for arranging a schedule in a way to minimize outside childcare. Offer a Saturday office hour, especially if you aren't on campus as much on weekdays. Teach one night class. Work with the administration in starting an on-campus daycare. Arrange complementary schedules with a colleague so that you can watch each other's children in childcare emergencies. Ask or hire a student to keep a time block free (while you're teaching) to watch your child in childcare emergencies. Arrange complementary schedules with your partner and use daycare part-time. Come home when your kids get out of school but then return to work (or work at home) in the evenings.

Finally, when exploring scheduling options, it is important to work within the culture of your school. Go in every day, even if you don't teach, and be as flexible as possible to avoid causing resentment.

Is academia more or less flexible than industry?

There wasn't consensus on this. In some ways academia is more flexible, but industry has improved a lot in the past five years (for example, with part-time or flex-time work).

An audience member noted that three of the four panelists were married to other mathematicians. This is perhaps not so unusual: Patti recalled that nationwide 80% of women mathematicians were married to other scientists. [From Ann Gibbons, "Key Issue: Two-Career Science Marriage," *Science*, 13 March 1992, pp. 1380-1381, quoted in Susan Landau, "A Study in complexity: Universities and the Two-Body Problem", *Association of Women in Mathematics Newsletter* (Vol. 24, No. 2), March-April 1994, p. 12.]

The panelists: Cheri Boyd, Michael Prophet, Patti Frazer Lock, and Stephanie Edwards.

How do you deal with childcare at conferences?

Usually people bring someone (grandparents, spouse, or a student) to baby-sit.

How do you work at home without being overcome by guilt when your children want to play with you?

The first suggestion was to determine what work can be interrupted (e.g. grading) and what can't (e.g. lesson plans). Then do the grading during the day, when it doesn't matter if you have to put it down suddenly to be with a child, and do the lesson plans at night after the kids are asleep. Another suggestion was to come home at 5pm or so and focus on your kids, and then do all your work after they go to bed.

Also remember that parents haven't spent all of history playing games. Even when mothers of the past were home with their kids, they were doing work within the home.

Can you get back to research after having children?

Patti acknowledged that she found it difficult to do research when her children were very young, although she did enough to earn tenure. She later changed her area of research and is still active.

What practical pieces of advice do you have on balancing your career and having a partner/spouse?

- Hire a cleaning person.
- Divide up chores (recognizing that you will each feel like you are doing more than half).
- Have a plan and share schedules (weekly, monthly, yearly).
- Write down information (chores, schedules) and post it.
- Don't accept late homework.
- Use Saturday mornings to prepare for the week, leaving evenings free.
- Eat dinner together every night, with the TV off.
- Plan special times together.
- Go to each other's activities.
- Get together with other couples (make a pact ahead of time that you won't straighten the house for them or they for you).
- Be committed to each other.
- Celebrate and commiserate together.
- Be flexible

What practical pieces of advice do you have on balancing your career and having younger/older children?

- Hire a cleaning person.
- Do NOT teach summer session.
- Have a daily schedule/routine.
- Use childcare near school.
- Have a backup plan (a colleague or student when childcare fails).
- Find ways to be productive while "on duty" (playpen, swing, blanket).
- Use students at school.
- Toddlers can play during informal meetings (warn ahead of time).
- Young children love chalkboards while you work at school.
- Young children can "play office" while you work at home.
- Children can watch videos in projection classrooms.
- Hide a special group of "work" toys for children to play with only when it's time for you to work.
- Older children can read quietly while you teach.
- Older children can help grade papers.
- Clearly set your priorities (you can't do it all).
- Keep in mind that no one is perfect, so go easy on yourself.

And finally, remember that the hard stuff is temporary. The good stuff continues.

Many thanks to our panelists for sharing their experiences in such a helpful way. Thanks also to John for his work in organizing and running the panel, and to Kevin Charlwood for sharing his notes from the discussion. A version of this article appeared in the February issue of *Concerns of Young Mathematicians*.

Have You Moved?

The MAA makes it easy to change your address. Please inform the MAA Service Center about your change of address by using the electronic combined membership list at MAA Online (www.maa.org) or call (800) 331-1622, fax (301) 206-9789, email maaservice@maa.org, or mail to MAA, P.O. Box 90973, Washington, DC 20090.

Mathematics and Mathematical Sciences in 2010: What Should Students Know?

by Tom Berger and Harriet Pollatsek

The question of what students should know is critical for the MAA Committee on the Undergraduate Program in Mathematics (CUPM) as it works to develop a new Curriculum Guide for departments, planned for late 2002. The situation today is much more complicated than in the decades when CUPM began formulating curricular recommendations. Institutions and students are more diverse, the number of mathematical sciences majors is falling, teacher shortages in mathematics and the sciences are becoming acute, the range of mathematics courses taught at the undergraduate level has increased dramatically, and the need for mathematical knowledge at the undergraduate level has grown significantly. The goal of the new Curriculum Guide is to help departments respond effectively to the current challenges in ways appropriate to their particular institutional settings and missions.

Last summer, CUPM solicited a dozen position papers on the undergraduate mathematics curriculum, and in September 2000 it held a conference with the authors. A study document entitled *Mathematics and Mathematical Sciences in 2010: What Should Students Know?* includes the position papers and some preliminary recommendations resulting from the conference. It is available on MAA Online at http://www.maa.org/cupm_text.html; a print version may be ordered as an MAA Reports volume. Both the conference and the publication were generously funded by the Calculus Consortium for Higher Education (CCHE). We regret that the CCHE acknowledgment was missing in some early distribution copies of the volume.

In April, CUPM sent a questionnaire to a sample of mathematical sciences departments in an effort to obtain data and examples to help shape, illustrate, and support the final recommendations of the Curriculum Guide. If you received a copy of the CUPM questionnaire, we urge you to respond, and if you know of a department that is engaged in successful program development or one gathering useful data to inform its planning, please let CUPM know about it.

As we move forward, we must consider what actions and expectations are appropriate for the different student populations whose needs we serve: (1) our own majors, including those preparing for careers in teaching, for direct entry into business, industry, or government, for graduate study in the mathematical sciences, and for graduate or professional study in other areas; (2) students preparing for majors in fields that make extensive use of the mathematical sciences; and (3) students who take only one or two courses in our departments. We are especially concerned about the needs of future teachers and recommend that all MAA members read the draft report prepared by the Conference Board of the Mathematical Sciences, Mathematical Education of Teachers, which is available online at http://www.maa.org/cbms/metdraft.

The CUPM study document includes the following preliminary recommendations.

- Students should achieve mastery of a rich and diverse set of mathematical ideas and should experience mathematics as an engaging field with contemporary open questions.
- Students should be able to think analytically and critically, to formulate and solve problems, and to interpret their solutions. They should understand and appreciate the value and validity of careful reasoning, precise definition, and close argument.
- Students should have experience applying knowledge from one branch of mathematics to another and from mathematics to other disciplines.
- Students should be able to use a variety of technological tools.
- Students should be able to communicate mathematics both orally and in writing; they should be able to read mathematics.

An Invitation from CUPM

We invite you to read the full study document *Mathematics and Mathematical Sciences in 2010: What Should Students Know?* Please discuss it with colleagues in your department and at your MAA sectional meetings, and send us feedback. We are particularly interested in responses to the following questions for the different groups of students you serve.

- Do the proposed recommendations identify the crucial issues and principles for a mathematics curriculum? What is missing? What should be deleted?
- Which mathematical ideas are most important, and how do we create thematic links among them? Which courses should students take in the first two years? Where should geometry and visualization fit in?
- How do we help students develop their critical thinking abilities?
- How can we best form productive alliances with other disciplines? The CUPM subcommittee on Calculus Reform and the First Two Years has conducted a series of workshops with faculty from other disciplines in the Curriculum Foundations Project. Look for the CRAFTY reports on the internet at http://academic.bowdoin.edu/math/faculty/barker/dissemination/Curriculum_Foundations. How can we translate what we learn from the CF project into effective and feasible programs?

- How does technology best serve student learning? How much technology should we incorporate into our curriculum to prepare our students for the workplace? How should institutions and departments support faculty in learning how to make pedagogically effective use of technology?

- How can we assist departments in making assessment productive and helpful, integral to their work and not just an activity done at the end of a project or to please a dean?

- What can departments do to counter declining enrollments in upper level courses and shrinking numbers of majors? What can be done to encourage more women and minorities to study mathematics and enter our profession? How can student recruitment, retention, and satisfaction be improved?

If you have any responses to these questions, comments on the study document, or suggestions of successful existing programs – especially ones for which data are available – we encourage you to send them either by e-mail to cupm-curric@maa.org or as hard copy to Harriet Pollatsek, Chair of CUPM, Department of Mathematics and Statistics, Mount Holyoke College. Members of CUPM look forward to hearing from you!

The MAA/Tensor Foundation Makes Twelve Awards

On March 9th the MAA and the Tensor Foundation announced twelve awards to support programs aiming to encourage women and girls to study mathematics. This is the seventh consecutive year in which such awards were made. Three of the awards were renewals. Following the usual pattern, the programs funded ranged from one-day mathematics awareness activities to monthly luncheons for women students and faculty on university campuses. For more information contact Florence Fasanelli at ffasanelli@juno.com. Here is the list of this year's awards.

Cathy Abeita, Southwestern Indian Polytechnic Institute, Albuquerque, NM
"Enhancing Mathematics Educational Opportunities for Native American Women at Southwestern Indian Polytechnic Institute"

Mathematics clubs for girls will be established in Pueblo schools by American Indian Teacher Aides who are studying mathematics at SIPI.

Diana B. Erchick, Ohio State University at Newark, Newark, OH
"Math-er-sci-ze Summer Mathematics Camp for Girls"

Fifty girls in grades 4-8 will have a week-long camp exploring connections between art and science, art and craft, literature and technology.

Gretchen Matthews and Jerry Dwyer, University of Tennessee, Knoxville, TN
"Mad About Math"

Female graduate students will organize school math clubs in three nearby middle schools for weekly meetings.

Tamar Schlick, New York University, New York, NY
"WoW: Women on Women Support Group at NYU"

A series of academic and cultural events for women pursuing careers in mathematics and science at the undergraduate, graduate, postdoctoral and professorial levels.

Mazin Shahin, Delaware State University, Dover, DE
"Girls Explorations in Mathematics and Science (GEMS) Program at Delaware State University"

Twenty female 9th and 10th grade students and two high school teachers will participate in an intensive one-week exploration of mathematical concepts applied to biological and chemical models.

Sonya S. Stanley, Samford University, Birmingham, AL

A special travel grant to participate in the Women Count Conference at 2001 MathFest.

Kathleen Sullivan, Seattle University, Seattle, WA
"Fair Challenges"

Thirty eighth-grade girls will attend a four-week mathematics and science camp with lengthy follow-up activities.

Carol G. Williams, Abilene Christian University, Abilene, TX

This project includes eight luncheons for women mathematics majors and women faculty, a mathematics day for 100 high school students and teachers, and travel for junior and senior women to the regional MAA meeting.

Elizabeth Yanik, Emporia State University, Emporia, KS
"Women Count: A Conference for Directors of Mathematics Outreach Programs for Young Women"

Experienced and prospective program directors will meet on August 1 at MathFest to learn about designing, running, funding, and assessing programs.

Renewals:

Angela Hare, Messiah College, Grantham, PA

The one-week math and computer science camp for teenage girls held in 2000 will be expanded to three camps: Girls Level 1, Girls Level 11, and Boys Level 1.

Tina Marcuso, The Sage Colleges, Troy, NY
"Girls and Math Equal Success (GAMES)"

Sixty female high school students and ten teachers attend a one-day program working with women pursuing undergraduate degrees in mathematics, computer science, biology and chemistry. In 2001 this program will be expanded into the evening with both formal and informal activities.

Lynda R. Weist, University of Nevada, Reno Reno, NV
"Girls Math & Technology Camp"

This six-day residential camp (with two follow-up Saturdays) for 112 middle school girls will be enhanced in 2001 with a web site, an electronic listserv, a network of community volunteers, and Spanish versions of various materials and forms for parents.

From an Acorn to an Oak: Establishing Lasting Reform in Teaching Practices

by Richard Jardine and Bonnie Gold

Implementing lasting reform is possible. That was the message of the panelists at the session *Growing an Oak Tree from an Acorn: Extending a New Program from a Few Innovators to the Whole Department* at the January Joint Meetings, sponsored by the Committee on the Teaching of Undergraduate Mathematics. The four panelists were Bernie Madison of the University of Arkansas, Jim Lewis of the University of Nebraska, Morton Brown of the University of Michigan, and Chris Arney, now a dean at the College of Saint Rose but formerly at the United States Military Academy. All are or were department chairs who played critical roles in ensuring the firm rooting of innovations in teaching and learning at their institutions. Each panelist offered suggestions on how to ensure that reform efforts lead to lasting change.

Bernie Madison led off the discussion, recalling his experiences at LSU and at the University of Arkansas. He first discussed factors influencing resistance to reform. Among these are program inertia, articulation agreements, conflicting priorities and motivation, existing culture and traditions, and personalization versus institutionalization. Reform proposals need to be viewed as worthwhile (as necessary improvements) and respectable, to have broad ownership. They should be exciting to faculty, students and administrators, and they should be easily "institutionalizable." One of the lessons learned in his experience was the need for people to drive reform with passion, but also be able to give up ownership and allow others to make changes when the reform was extended to the whole department. Additionally, support from the administration was a necessity for ensuring growth of the implemented changes.

In his presentation, Mort Brown recalled the calculus reform pilot program at the University of Michigan. The search for a text led to the change process there. The calculus program at Michigan is a huge operation, involving 5,000 students per year, incorporating rooms of 30 students working at tables, team homework, and gateway tests. Extensive training of 30 to 60 new instructors per year is an important component of the program. The process was expensive to implement, and NSF funding provided the initial impetus. The university now provides support for the innovative practices in mathematics instruction, in part because they have led to improved relationships with other university departments. Positive aspects of the implementation at Michigan include an emphasis on teaching and the development of methods for assessing teaching experience. There are problems too: reform has not moved into the second year, and about one-third of the senior faculty chose not to be involved, restricting themselves to traditional teaching practices. Some hesitate to chop down old oaks that are already a valuable part of the landscape.

Chris Arney extended the analogy of the "acorn to the oak" to the collective effort that is essential to improving the educational landscape. As a catalyst for change at the United States Military Academy, an institution which sometimes describes itself as a bastion of nearly "200 years of tradition unhampered by progress," he found that the successful implementation of educational reform was accomplished only after first getting many to participate in the design of the change process, then effectively "selling" the process, and finally obtaining and sustaining commitment for the reforms. The change process begins by reaching consensus with colleagues on the goals of reform. Monitoring the implementation of change through continuous assessment ensures that innovations move toward the agreed-upon goals. Colleagues must have ownership of the change process; many must participate in the planting and nurturing of the reforms if they are to take root and remain viable.

At the University of Nebraska, a significant impetus for change was local school districts' use of graphing calculators. Incoming students did not understand why the university did not accept technology in their learning when their high schools did! Jim Lewis saw the University of Nebraska make the transition from "no calculators allowed" to eGrade, a web-based examination system that is now a significant part of the university's campus culture. Innovation at Nebraska was implemented conservatively. After support for reform was apparent in the national mathematics community, a local alumni grant of $55,000 made the change possible. When the university provided funding and release time for faculty willing to participate in the process, young research faculty began to volunteer. Faculty consensus was achieved in 1994 to adopt the Harvard calculus materials in all sections of calculus I and II and to use graphing calculators, writing projects, and group work. Reform of the mathematics curriculum was tied to general education reform ongoing at the university. Involving other disciplines in the process solidified change, to the extent that the testing center originally designed to support changes in mathematics teaching now supports other disciplines across the university.

Educational change is a natural, evolutionary process. Leaders advocating change must depersonalize the reform process and obtain the support of other faculty, within their department and across disciplines, and of the administration. If change is to be truly effective, all need to view reform as worthwhile, including students. Solidifying change is possible through continual assessment to ensure that reforms are appropriate for the local landscape. Acorns nurtured by many have the greatest chance to become mighty oaks. ■

Richard Jardine teaches at Keene State College in New Hampshire. Bonnie Gold is chair of the Mathematics Department at Monmouth College in New Jersey.

National Elections Underway

Ballots for this year's MAA national elections were mailed at the beginning of April. To assure that your vote is counted, your completed ballot must be postmarked before June 1, 2001. Don't miss the chance to influence the future direction of the Association: be sure to vote!

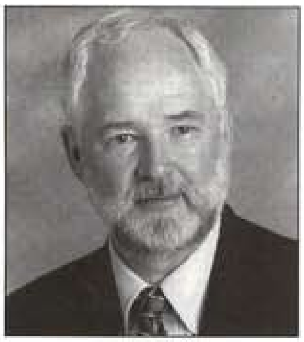
Candidates for President-Elect:

Ronald Graham

John Kenelly

Hugh Montgomery

Candidates for 1st Vice-President:



Carl Cowen

Genevieve Knight

William Yslas Velez

Candidates for 2nd Vice-President:

Susanna S. Epp

Joseph A. Gallian

Celestino Mendez

Kenneth A. Ross chaired the Nominations Committee. Other members were William A. Hawkins, Jr., T. Christine Stevens, David R. Stone, and Paul Zorn.

Results of Governor Election 2001

1. **Jasper E. Adams**, Stephen F. Austin State University, Texas
2. **Ruth I. Berger**, Luther College, Iowa
3. **Connie M. Campbell**, Millsaps College, Louisiana-Mississippi
4. **Ralph A. Czerwinski**, Millikin University, Illinois
5. **Jerrold W. Grossman**, Oakland University, Michigan
6. **E. Robert Heal**, Utah State University, Intermountain
7. **Michael D. Hvidsten**, Gustavus Adolphus College, North Central
8. **Mario Umberto Martelli**, Claremont McKenna College, Southern California
9. **Betty Mayfield**, Hood College, Maryland/DC/ Virginia
10. **Marilyn Repsher**, Jacksonville University, Florida
11. **Kay B. Somers**, Moravian College, EPADEL

Grant Funding Available

The Calculus Consortium for Higher Education is a small non-profit public charity whose mission is to improve the teaching of mathematics in secondary schools, two-year colleges, four-year colleges and universities. It supports workshops, meetings, conferences or research projects that deal with that mission. Grant requests are hereby solicited in those four areas. Grants are usually for 1 year and for less than $25,000. Proposals should be less than 5 pages, accompanied by a budget using NSF Form 1030. Send proposals by November first to: CCHE, P.O. Box 22333, Carmel, CA 93922-0333; Email: cche@redshift.com; Fax: (831) 624-7571 for consideration at the annual meeting of the Board of Directors in early January of each year. Requests for an earlier review date will be considered on an individual basis. If you have any questions, please contact Thomas Tucker, Mathematics Department, Colgate University, Hamilton, NY 13346, Email (preferred): ttucker @mail.colgate.edu.

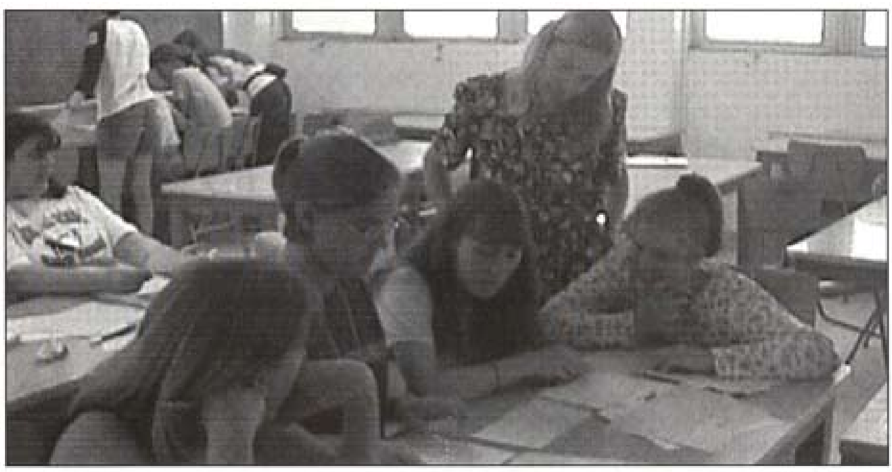
Women Count: A Conference for Directors of Mathematics Outreach Programs for Young Women

by Elizabeth Yanik

The Women and Mathematics Network, under the auspices of the MAA Committee on the Participation of Women, is organizing a conference on outreach programs for young women. The conference will be held in Madison, Wisconsin on August 1, 2001, just before MathFest 2001. The purpose of the conference will be to disseminate information about current successful outreach programs for young women and to encourage the establishment of more programs throughout the nation. Funding for the conference is being provided by the National Security Agency, the National Science Foundation, and the Tensor Foundation.

Participants In MASTER IT (Mathematics and Science to Explore careers-Investigating Together) an NSF funded summer outreach program at Emporia State University experiment with placing casts on soda bottles.

Both experienced and prospective program directors are invited to apply to participate in the conference. Team entries that pair an experienced director with a prospective director from the same geographic region will be especially welcome because this enhances the opportunities for continued mentoring. Partial travel support will be provided. Planned events include a workshop on grant writing, breakout sessions grouped by one day programs versus week(s)-long programs, and programs for high school students versus those with a middle school focus. Guest speakers will lead sessions on such issues as selection of program format, recruitment of young women, types of hands-on activities, possible funding sources, and assessment procedures. Representatives from the National Security Agency, Mathematical Association of America, Tensor Foundation, and the National Science Foundation will be invited to speak on their programs that assist and support mathematics outreach activities. A special session on assessment issues will also be organized.



At Emporia State University, young women in MASTER IT, an NSF funded outreach program, work together to break a secret code.

The organizers hope that one major outcome of this conference will be the formation of regional support networks for prospective directors of outreach programs. Participants in Women Count will receive a directory of all participants and short descriptions of existing programs. A follow-up session will be held at the national AMS-MAA meetings to be held in San Diego, CA in January 2002. More information about the conference and an application form may be found on the Women and Mathematics Network web page at http://www.mystery.com/WAM/. ■

Faculty Isolated by Discipline

by John D. Fultons

The mathematical sciences embrace several disciplines including (but not limited to) mathematics, applied mathematic, computer science, mathematics education, operations research, and statistics. Many departments that include mathematics also include others among these disciplines. A faculty member is isolated by discipline if s/he is the only faculty member with expertise in that discipline in a department. More than one faculty member could be isolated by discipline if they are junior faculty members and are the only faculty members with expertise in that discipline within a department. This article concerns issues related to such faculty.

At the 2001 Joint Mathematics Meetings in New Orleans, four panelists discussed issues related to faculty isolated by discipline. Panel moderator was Bernard Madison, then chair of the MAA Committee on the Profession. Madison is MAA Visiting Mathematician on leave from the University of Arkansas at Fayetteville. The panelists were John Fink, Mathematics and Computer Science Department Chair at Kalamazoo College; Henry Walker, the Rosenthal Professor of Natural Science and Mathematics at Grinnell College and Secretary/Treasurer and 2001 Symposium Chair of the ACM Special Interest Group on Computer Science Education (SIGCSE); Annie Selden, Professor of Mathematics at Tennessee Technological University and Coordinator of the SIGMAA on Research in Undergraduate Mathematics Education (SIGMAA on RUME); and Donald Bentley, Professor of Statistics in the Department of Mathematics at Pomona College. The author was panel organizer. Panel sponsors were the MAA Committee on the Profession, the SIGMAA on RUME, and the ASA-MAA Committee on Statistics.

John Fink described a near complete turnover in faculty in mathematics and computer science at Kalamazoo College. Traditional mathematics expertise was diversified to include two computer scientists, a statistician, and an applied mathematician. Before the new faculty members were hired, the department had no statistics educator and only one faculty member in computer science, a chemist who had obtained a master's degree in computer science. To advise the department in the hiring process and to prepare for faculty diversity, Fink brought to the campus expert visitors, computer scientist Henry Walker and statistician Thomas Moore, both from the Mathematics and Computer Science Department at Grinnell College. Their advice helped develop expectations for the positions and led to the inclusion of faculty from other departments in the search committees. Information in their reports was used in conducting the searches and also helped educate the provost as to the unique professional needs of those sought. The statistics report contained a careful documentation on the need for a statistician to engage in professional consulting.

Anticipating possible isolation of the faculty to be hired, Fink took interviewees for the positions to visit faculty with like expertise at Western Michigan University. The applied mathematics interviewees also were taken to visit scientists at a nearby pharmaceutical company.

The four new faculty members now have been hired. The applied statistician collaborates with faculty from other departments, works with seniors on capstone theses, engages with students in off-campus consulting, works with Western Michigan University faculty, works with the campus Institutional Research office, and participates as an officer in a local ASA Chapter. The applied mathematician consults at the pharmaceutical company, develops curricula with faculty from Chemistry and Biology, and collaborates in research with faculty at three universities. The computer scientists participate in SIGCSE; one served on the AP Computer Science Development Committee; and both offered courses in areas of their research.

Fink was assisted in building perspectives on the applied mathematics, computer science, and statistics disciplines by such publications as *Heeding the Call for Change: Suggestions for Curricular Action* (Steen, editor, MAA, 1992) and *On the Shoulders of Giants* (Steen, editor, National Academy Press, 1990). Presentations on statistics education by Joan Garfield (1996), Thomas Moore (1998), Alan Rossman (1998), and David Moore (1998) at the Board on Mathematical Sciences (BOMS)Depart-ment Chairs Colloquia also helped Fink understand the particular needs of statistics faculty. Fink credits a presentation by Don Bentley at the 1997 Chairs Collo-quium with imparting understanding of the special problems encountered by faculty isolated by discipline as well as potential solutions for some of those problems.

Henry Walker emphasized that many of the special circumstances surrounding computer science programs today seem strikingly similar to those discussed in 1988 in the Joint MAA/ACM/IEEE Task Force Report, "Teaching Computer Science Within Mathematics Departments." Enrollments in computer science have more than doubled during 1995–1999; yet new computer science PhDs have remained constant at about 1100 during the same period. Many small colleges competed for the 35 new PhDs in computer science who chose higher education positions in departments that did not award PhDs. Almost 60% of the 1999 new PhDs whose employment status was known work outside of United States higher education.

Walker indicated that content of a given computer science course may change radically from semester to semester and make course and curricular development a time-consuming effort. Remaining current in computer science education is nearly a full-time task. Walker noted that on average a mathematics reader can grade 32 AP calculus exams in the same time it takes a computer science reader to grade 17 computer science exams. This difference in average grading time, Walker stated, is an indicator of the additional time computer science faculty must spend in student grading.

Walker urged that isolated faculty members be encouraged to join special interest groups in their research areas (ACM has 36 such groups). He pointed to other collaboration opportunities through service on NSF panels and in AP readings. Regional networking opportunities exist through participation in activities of the Consortium for Computing in Small Colleges, the Liberal Arts Computer Science Consortium, MAA sections, ACM chapters, and state Academies of Science. He also highlighted an idea he attributed to Arnold Ostebee (of St. Olaf College): devoting a week each year to a visit by an on-going group of mentors might help relieve the isolation of junior faculty in computer science. These would lead curricular discussions, discuss the needs of isolated faculty members with administrators, give talks about their research, talk with students, and present colloquium addresses.

To remain current in computer science education, Walker recommended that administrators encourage and provide support for computer science faculty participation in mini-courses, short-courses, and accelerated versions of standard courses offered at workshops, summer institutes, and conferences of professional societies.

Annie Selden spoke about the scarcity of PhD recipients in mathematics education. Few journals focus on research in undergraduate mathematics education. Mathematics education faculty members often, and sometimes primarily, teach pre-service teachers. Their large service expectations may not leave sufficient time, and generally do not provide source material, for research. Many research techniques in mathematics education are adapted from psychology, anthropology, and sociology and depart markedly from traditional theorem-proof research familiar to mathematicians. Selden pointed to a number of professional societies of interest to those in mathematics education. Opportunities for networking and collaboration abound in such organizations as the American Educational Research Association, the Association of Mathematics Teacher Educators, the Research Council on Mathematics Learning, the National Council of Teachers of Mathematics, and the International Group for the Psychology of Mathematics Education. The SIGMAA on RUME holds annual conferences on research in undergraduate mathematics education, sponsors sessions at MAA meetings, provides mentoring mini-grants, and maintains a website and a listserv. Their web site (http://www.maa.org/sigmaa/arume/) provides information on conferences, places to publish, and web resources; a literature database is under construction.

The SIGMAA on RUME is preparing a document entitled *Guidelines for Programs and Departments in Mathematical Sciences Concerning Mathematics Education and Specialistsin Mathematics Education.* "The Undergraduate Program" portion of these guidelines will complement the MAA Guidelines for Programs and Departments in Undergraduate Mathematics (the "new MAA Guidelines," available on MAA Online). The SIGMAA will develop additional guidelines for graduate programs in undergraduate mathematics education. "The Undergraduate Program" guidelines, when finalized, will contain sections on educational background, scholarship, and teaching assignments of mathematics education faculty in departments of mathematics. "Establishing mathematics education communities in departments of mathematics" and "The role of research in teaching and learning in guiding instructional decisions" will be other sections. The document now exists in draft form and, when approved, will be placed on the SIGMAA on RUME web site.

Don Bentley, the only statistics faculty member at Pomona College, has educated over 50 undergraduate students who have earned doctorates in statistics or equivalent fields. He helped found the Statistics in the Liberal Arts Workshop (SLAW). Its concerns include tenure-earning issues confronting young statisticians in mathematics departments. Bentley is a leader of the Isolated Teachers of Statistics. In addition Statistics Education now has its own SIGMAA. The need, indeed the requirement, that the statistician be engaged in professional consulting has been advanced by these organizations as the need for statistical expertise as qualification to teach statistics courses.

As a member of the ASA-MAA Committee on Statistics and as a member of the Task Force to Review the 1993 MAA Guidelines, Bentley successfully pressed for inclusion of guidelines on issues that concern faculty isolated by discipline in the new MAA Guidelines. An ASA-MAA Committee on Statistics report provided the catalyst that led to the new Guidelines document. In November 1997, Bentley made a presentation, focused on faculty isolated by discipline, to the BOMS Department Chairs Colloquium on the new MAA Guidelines. One guideline pertaining to faculty isolated by discipline says that, "if the department has only one or two faculty members in a discipline, it should seek outside persons to serve as advisors for departments and mentors for these isolated faculty members early in their careers." It is to be hoped that the panel and the new Guidelines help make mathematics departments more attentive to the needs of faculty members who are isolated by discipline. ■

John Fulton is Professor of Mathematics at Virginia Tech and currently is director of a project whose goal is to foster more data-based decision making at the University. He is Chair of the MAA Committee on the Profession.

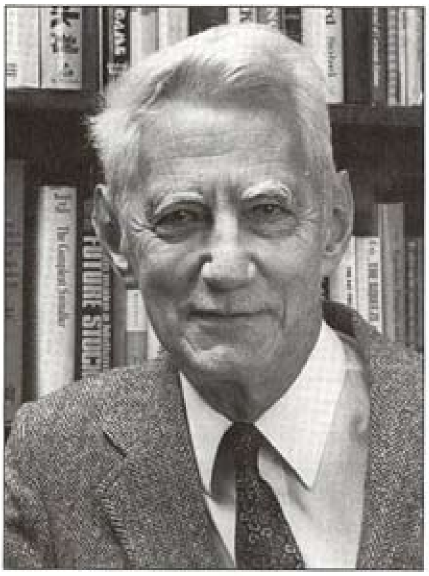
Claude Shannon, 1916–2001

by Keith Devlin

Mathematician Claude Shannon died on Saturday February 22, aged 84, after a long struggle with Alzheimer's disease. But his intellectual legacy will live on as long as people communicate using phone and fax, log on to the Internet, or simply talk about "information" as a commodity that can be measured in "bits" and shipped from place to place. The approach to information and communication that Shannon laid out in his groundbreaking paper "A Mathematical Theory of Communication," published in the Bell System Technical Journal in 1948 and republished virtually unchanged in the pamphlet *The Mathematical Theory of Communication,* written with Warren Weaver the following year and published by the University of Illinois Press, remain current to this day. (Note how the "a" of his paper became "the" in the Shannon-Weaver version.)

Shannon was born in Michigan in 1916. After obtaining degrees in both mathematics and engineering at the University of Michigan, he went to MIT to pursue graduate studies in mathematics. There he came into contact with some of the men who were laying much of the groundwork for the information revolution that would take off after the Second World War, notably the mathematician Norbert Wiener (who later coined the term cybernetics for some of the work in information theory that he, Shannon, and others did at MIT and elsewhere) and Vannevar Bush, the dean of engineering at MIT (whose conceptual "Memex" machine foretold the modern World Wide Web and whose subsequent achievements included the establishment of the National Science Foundation).

In the early 1930s, Bush had built a mechanical, analog computer at MIT called the Differential Analyzer, designed to solve equations that were too complex for the (mechanical) calculating machines of the time. This massive assemblage of cog wheels, shafts, gears, and axles took up several hundred feet of floor space, and was



Claude Shannon

powered by electric motors. Preparing the device to work on a particular problem required physically configuring the machine, and could take two or three days. After the machine had completed the cycle that constituted "solving" the equation, the answer was read off by measuring the changes in position of various components.

Always a "tinkerer," Shannon took to working with the Analyzer with great enthusiasm. At Bush's suggestion, for his master's thesis, he carried out a mathematical analysis of the operation of the machine's relay circuits. In 1938, he published the results of this study in the *Transactions of the American Institute of Electrical Engineers* under the title "A Symbolic Analysis of Relay and Switching Circuits."

Bush's seemingly mundane motivation for having Shannon do the work was the telephone industry's need for a mathematical framework in which to describe the behavior of the increasingly complex automatic switching circuits that were starting to replace human telephone operators. What Shannon produced far transcended that aim. The ten page article that he published in the *Transactions of the AIEE* has been described as one of the most important engineering papers ever written. And with good reason: quite simply, it set the stage for digital electronics.

Shannon began by noting that, although the Analyzer computed in an analog fashion, its behavior at any time was governed by the positions of the relay switches, and they were always in one of just two states: open or closed (or on or off). This led him to recall the work of the nineteenth century logician George Boole, whose mathematical analysis of the "laws of thought" was carried out using an algebra in which the variables have just the two "truth values" T and F (or 1 and 0). From there it was a single – but major – step to thinking of using relay circuits to build a digital "logic machine" that could carry out not just numerical computations but also other kinds of "information processing."

In 1940, Shannon obtained his doctorate in mathematics, and went to the Institute for Advanced Study at Princeton as a National Research Fellow, where he worked with Hermann Weyl. The following year, he took a position at the Bell Telephone Laboratories in New Jersey, joining a research group who were trying to develop more efficient ways of transmitting information and improving the reliability of long-distance telephone and telegraph lines.

In the 1950s, Shannon became interested in the idea of machine intelligence, and was one of the conveners – together with his soon to be famous mentees John McCarthy and Marvin Minsky – of the now legendary 1956 conference at Dartmouth College in New Hampshire that is generally acknowledged as the birth of artificial intelligence (or AI), as it later became known. But while others (McCarthy and Minsky among them) would become identified with AI, Shannon's name will be forever associated with the theory of information and communication that the world learned of from the Shannon-Weaver pamphlet.

Prior to Shannon's work, mathematicians and engineers working on communications technology saw their job as finding ways to maintain the integrity of an analog signal traveling along a wire as a fluctuating electric current or through the air as a modulated radio wave. Shannon took a very different approach. He viewed "information" as being completely encoded in digital form, as a sequence of 0s and 1s – which he referred to as "bits" (for "binary digits"), following a suggestion of his Princeton colleague John Tukey. In addition to providing the communications engineers with a very different way of designing transmission circuits, this shift in focus also led to a concept of "information" as an objective commodity, disembodied from a human "sender" or "receiver." After Shannon, the name of the game became: how can you best send a sequence of discrete electrical or electromagnetic pulses from one point to another?

A particular consequence of this new approach, which Shannon himself was not slow to observe, was that whereas even a small variation in an analog signal distorts – and can conceivably corrupt – the information being carried by that signal, the discrete yes-or-no/on-or-off nature of a digital signal means that information conveyed digitally is far less prone to corruption; indeed, by adding extra bits to the signal, automatic error detection and correction can be built into the system. (This feature of digital coding would, decades later, enable Napster users to download music files over the phone lines and play the latest pop music on their desktop PC with a fidelity limited only by the quality of the computer's sound system. It is further exemplified by the oft-repeated claim of CD manufacturers that you can drill a centimeter hole in your favorite music CD and it will still play perfectly.)

From a mathematical point of view, arguably the most significant aspect of Shannon's new, digital conception of information is that it provides a way to measure information – to say exactly how much information a particular signal carries. The measure is simple: you simply count the minimum number of bits it takes to encode the information. To do this, you have to show how a given item of information can be arrived at by giving the answers to a sequence of yes/no questions. For example, suppose that eight work colleagues apply for a promotion: Alberto, Bob, Carlo, David, Enid, Fannie, Georgina, and Hilary. After the boss has chosen which person will get the position, what is the minimum number of yes/no questions you have to ask to discover his or her identity? A few moments thought will indicate that the answer is 3. Thus, the information content of the message announcing who got the job is 3 bits. Here is one way to arrive at this figure:

First question: Is the person male?
That cuts down the number of possibilities from 8 to 4.

Second question: Does the person's name end in a vowel?
That reduces the field to a single pair.

Third question: Is the person the taller of the two?
Now you have your answer.

Of course, this particular sequence of questions assumes that no two applicants are the same height. Moreover, I rigged it to have four males and four females, with carefully chosen names. But the principle will work for any example. All you need is a framework within which a series of yes/no questions (or other binary decisions) will repeatedly halve the number of possibilities until just one remains. (If the number of possibilities at the outset is not a power of 2, there will be a little redundancy in the decision sequence, but you'll still get a measure of the information content. For example, if there were just 7 candidates, the information content of the final decision will still be 3 bits.)

Building on this simple idea, Shannon was able to develop an entire quantitative theory of information content that has proved to be of enormous importance to the engineers who have to decide how much "channel capacity" a particular communications network requires at each point. So complete was his initial analysis that, although you can find the theory described in many contemporary textbooks, you might just as well go back to his original 1949 pamphlet with Weaver. Except for one thing: the name "information theory" is misleading.

As has been pointed out by a number of workers (including myself, in my 1991 book *Logic and Information*), Shannon's theory does not deal with "information" as that word is generally understood. Instead, it deals with data – the raw material out of which information is obtained. (See my book *InfoSense* for a discussion of the distinction.) In Shannon's theory, what is measured is the size of the (binary) signal. It does not matter what that signal denotes. According to Shannon's measure, any two books of 100,000 words have exactly the same information content. That's a useful (if misleading) thing to say if your goal is simply to transmit both books digitally over the Internet. But if one is an instruction manual for building a nuclear-powered submarine and the other a trashy novel, no one would claim that the two contain the same amount of "information."

By the same token, anyone who thinks that the information content of Shannon's 1948 paper can be captured by the statement that it is "100 pages worth" must surely have been in a trance for the past fifty years in which Shannon's ideas have transformed the world. ■

Keith Devlin is Dean of Science at Saint Mary's College of California, in Moraga, California, and a Senior Researcher at Stanford University. His latest book is The Math Gene: How Mathematical Thinking Evolved and Why Numbers Are Like Gossip, published by Basic Books. This article first appeared in Devlin's Angle, his monthly column on MAA Online.

MAA Contributed Papers Sessions: San Diego Joint Mathematics Meetings, January 6–9, 2002

PRELIMINARY ANNOUNCEMENT

The organizers listed below solicit contributed papers pertinent to their sessions. Sessions generally limit presentations to ten minutes, but selected participants may extend their contributions up to twenty minutes. Each session room contains an overhead projector and screen; blackboards will not be available. Persons needing additional equipment should contact, as soon as possible, but in any case prior to September 14, 2001, the session organizer whose name is followed by an asterisk. Please note that the dates and times scheduled for these sessions remain tentative.

MAA CP A1 History of Mathematics in the Second Millennium
Sunday and Monday mornings
Janet L. Beery*, University of Redlands, 1200 E. Colton Avenue, Redlands, CA 92373; (909) 793-2121 x3118; fax: (909) 793-2029; beery@uor.edu
C. Edward Sandifer, Western Connecticut State University

We invite original contributions to any portion of the history of mathematics of the second millennium BCE, the second millennium CE, or both, as well as expository discussions of this history and ideas for engaging students with it. Presentations connecting the mathematics history of the two millennia are especially welcome, as are reports of innovative uses of the mathematics history of the two millennia in the classroom.

MAA CP B1 Mathematics Courses for Teachers, K-12
Sunday and Monday mornings
Ira J. Papick*, University of Missouri, Columbia, Missouri 65211; (573) 882-7573; fax: (573) 882-1869; mathip@showme.missouri.edu
Duane Porter, University of Wyoming, Diane Spresser, National Science Foundation.

There are numerous contemporary reports and studies that serve as catalysts to think more deeply about the mathematical qualifications needed for effective teaching in grades K-12. Among these are the NCTM Principles and Standards for School Mathematics, the insightful work of Liping Ma, and the CBMS Report on the Mathematical Education of Teachers. Research shows that mathematics students achieve more when taught by teachers with strong mathematical content preparation. Yet, because of the current national shortage of qualified mathematics teachers, many practicing teachers have backgrounds that are less than adequate in mathematics. This session seeks papers on innovative mathematics courses that target (a) middle/high school teachers who are teaching mathematics "out of field," (b) those teaching mathematics at the middle grades with elementary certification, or (c) preservice mathematics students (or inservice teachers) for whom a capstone experience would better prepare them for the demands of the high school mathematics classroom.

MAA CP C1 Integrating Mathematics and Other Disciplines
Sunday and Monday mornings
William McCallum*, University of Arizona, Tucson, AZ 85721, (520) 621-6697; fax: (520) 621-8322; wmc@math.arizona.edu
Deborah Hughes Hallett, University of Arizona,
Yajung, SUNY, Farmingdale

The session will present:
• discussions of the content of current mathematics courses in the first two years in light of the way other disciplines use mathematics and the expectations they have of our students
• discussions of how applications of mathematics in other disciplines can be incorporated into mathematics courses in a way that enhances mathematical understanding
• presentations of exemplary courses or course modules.

Submissions are encouraged from teachers in engineering, the physical and social sciences, and management and public policy, showing examples of how mathematics is used in their courses. Submissions are also encouraged from mathematicians who have successfully incorporated such material into their courses.

MAA CP D1 Innovative Uses of the World Wide Web in Teaching Mathematics
Sunday and Monday mornings
Marcelle Bessman*, Jacksonville University, Jacksonville, FL 32224;(904) 744-3950 x7304;mbessma@ju.edu
Brian Smith, McGill University

This contributed paper session will focus on creative uses of the World Wide Web in mathematics instruction. Proposals are solicited on original uses of Web resources in the classroom. We are looking for presentations involving the use of real data sets, instructional materials, interactive simulations, video conferencing, or other topics of interest for educators who are currently using, or planning to use, the Web in their classes. The session is sponsored by The MAA Committee on Computers in Mathematics Education (CCIME).

MAA CP E1 Initiating and Sustaining Undergraduate Research Projects and Programs
Sunday and Monday afternoons
John Swallow*, Davidson College, P. O. Box 1719 / 200 D Road, Davidson, NC 28036-1719; (704) 894-2316; fax: (704) 894-2005; joswallow@davidson.edu
Suzanne Lenhart, University of Tennessee
Daniel Schaal, South Dakota State University

This session seeks presentations from faculty supervisors of undergraduate research who have insights and experience which would assist others, either in creating individual undergraduate research projects or in creating and maintaining longer-term undergraduate research programs. The broad spectrum of undergraduate research, from small projects in courses to honors projects and full-fledged summer research programs, will be represented.

MAA CP F1 Learning to Prove in Cooperative Learning and Technology Supported Environments
Sunday afternoon
G. Joseph Wimbish, Huntingdon College, Montgomery, AL

36106; (334) 283-8149; fax: (334) 283-5413; jwimbish@huntingdon.edu
Connie Campbell, Millsaps College
Draga Vidakovic, Georgia State College

For this session we welcome reports of research along with classroom experiences on topics relating to helping students learn to prove. We would particularly welcome those contributions arising from explicit use of cooperative learning with technology supported environments. Topics of interest could include sources of difficulties and misconceptions, importance of pedagogical approaches in identifying and overcoming difficulties and misconceptions, learning to formulate ideas within groups, and the respective roles of discovery, construction, empirical methods and refutations. We would also be interested in topics that explore sources of student theorems and the methods and timing of instructor intervention when working with cooperative learning.

MAA CP G1 Changing Student Views Regarding the Usefulness of Mathematics in Order to Increase the Number of Mathematics Majors
Sunday afternoon
Sarah Mabrouk*, Framingham State College, 100 State Street, PO Box 9101, Framingham, MA 01701-9101, (508) 626-4785; fax: (508) 626-4003; smabrouk@frc.mass.edu

Many students select a major based on future earnings rather than interest/aptitude, choosing not to major in mathematics because they do not view mathematics as useful for life/career. While encouraging students to choose a major that fits their interests/abilities, mathematics departments must be concerned about the number of majors in order to maintain/expand the department. If we demonstrate how studying mathematics is useful in the "real world" or leads to an interesting career then we enable students to pursue their interests in mathematics while maintaining/expanding the department. This session invites papers highlighting efforts of departments to attract mathematics majors. Of interest are activities such as lectures, workshops, math clubs, Math Days, Math Fairs, and Career Days designed to help students to view mathematics as useful and to attract majors. Of special interest are the benefits to students, the affect on the number of mathematics majors, and the benefit(s) to the department.

MAA CP H1 Computational Mathematics in Linear Algebra and Differential Equations
Sunday and Monday afternoons
Rich Marchand*, SUNY Fredonia, Fredonia, NY 14063; (716) 673- 3871; fax: (716) 673-3804; marchand@cs.fredonia.edu
Elias Deeba, University of Houston-Downtown
Tim McDevitt, Millersville University

Recent advances in computer algebra systems, spreadsheets and calculators facilitate numerical investigations of many meaningful problems in linear algebra and differential equations. Such investigations often increase students' understanding of mathematical concepts and empowers them with the capabilities to analyze more "real world" problems. This session invites papers from these disciplines where these technologies are utilized. The session is sponsored by The MAA Committee on Computers in Mathematics Education (CCIME).

MAA CP I1 Deep Understanding of School Mathematics Needed by Teachers
Monday afternoon
Albert D. Otto*, Campus Box 4520, Illinois State University Normal, IL 61790-4520; (309) 438-5767; fax: (309) 438-5866; otto@ilstu.edu
Catherine Murphy, Purdue University-Calumet
Phil Quartararo, Southern University

The CBMS Report of the Mathematical Education of Teachers has as a central theme a call for K-12 teachers to develop a deep understanding of fundamental school mathematics. Papers in this session should illustrate, through specific and well-developed examples, what it means to understand school mathematics deeply, how such understanding can be fostered, and how such understanding can be demonstrated. All papers should show a clear connection to the CBMS Report. This session is sponsored by the MAA Committee on the Mathematical Education of Teachers (COMET).

MAA CP J1 Best Practices in Undergraduate Statistics Education
Tuesday morning
Mary M. Sullivan*, Rhode Island College, 600 Mt. Pleasant Avenue; Providence, RI 02908; (401) 456-9851; fax: (401) 456-8379; mmsullivan@ric.edu
Carolyn Cuff, Westminster College

Many contemporary courses in statistics include classroom/laboratory activities and/or projects that require active involvement with real data, analysis enhanced by technology, and communication of the results. Faculty who teach statistics and include activities and projects in their courses are invited to contribute papers that describe successfully implemented activities or projects. Faculty will demonstrate the activity during the session and handouts are expected. Activities can be selected from a range of courses, from those in which only a portion of the course examines statistics through upper level statistics courses.

MAA CP K1 Re-Defining What a Modern "College Algebra" Experience Means
Tuesday and Wednesday mornings
Sheldon P. Gordon*, SUNY at Farmingdale, Farmingdale, NY 11735; (516) 451-4720; fax: (516) 420-2211; gordonsp@farmingdale.edu
Florence S. Gordon, New York Institute of Technology
Arlene H. Kleinstein, SUNY at Farmingdale
Mary Robinson, University of New Mexico, Valencia Campus
Linda Boyd, Georgia Perimeter College
Rick Gillman, Valparaiso University

The term "college algebra" encompasses a wide variety of offerings ranging from elementary algebra through college algebra/trigonometry courses and even precalculus courses. What is common is an image of the students who take such courses - those who lack some or all of the traditional algebraic skills needed for calculus. Today, there are many pressures to re-define all of these traditional courses which have prompted a major MAA curriculum initiative to re-define what a "college algebra" experience should be. This session seeks contributed papers that will: (1) Present new visions for any of the courses that fall under the "college algebra" rubric; (2) Present new visions for courses and programs in Quantitative Literacy; (3) Describe individual experiences implementing such courses. This includes new content, new pedagogical features (collaborative learning, student projects, communication of ideas, etc), assessment and evaluation, student reactions to the courses, and so forth; (4) Discuss what is known about enrollment trends relating to these courses; (5) Describe the connections between college algebra courses and courses in other disciplines; and (6) Describe connections between college algebra courses and programs in quantitative literacy. The session is being co-sponsored by the MAA Task Force on the First College Level Mathematics Course, the Committee on the Undergraduate Program in Mathematics (CUPM), the Committee on Calculus Reform At the First Two Years (CRAFTY), the Committee on Two-Year Colleges (CTYC), the Committee on Quantitative Literacy (CQL), and the Committee on Service Courses.

MAA CP L1 Strategies for Increasing the Diversity of Students in Mathematics

Tuesday morning

William Yslas Velez*, University of Arizona, Tucson, AZ 85721; (520) 621-2259; fax: (520) 621-8322; velez@math.arizona.edu
Marjorie Enneking, Portland State University
William Hawkins, SUMMA
Michael Freeman, University of Kentucky
Robert Megginson, University of Michigan
Wade Ellis, West Valley College

This session will present strategies for recruiting students from diverse backgrounds into mathematics; programs to support high success rates and level of achievement by these students; and faculty development initiatives which help faculty and departments initiate such programs. Presenters will describe methods for evaluating such programs and evidence to document the success of their program.

MAA CP M1 Using Examples from Sports to Enhance the Teaching of Mathematics

Tuesday morning

Robert Edward Lewand*, Goucher College, 1021 Dulaney Valley Road, Baltimore, Maryland 21204; (410) 337-6239; fax: (410) 337-6408; blewand@goucher.edu
Howard Penn, U.S. Naval Academy

The world of sports provides numerous applications that can enrich the teaching of various mathematics courses. This session seeks talks on the successful use of sports applications to enrich the teaching of any college level mathematics course.

MAA CP N1 Classroom Demonstrations and Course Projects That Make a Difference

Tuesday and Wednesday afternoons

David R. Hill*, Temple University, Philadelphia, Pa. 19122; (215) 204-1654; fax: (215) 204-6433; hill@math.temple.edu
Sarah Mabrouk, Framingham State College
Lila F. Roberts, Georgia Southern University

The use of course projects and classroom demonstrations enables instructors to show students that mathematics is meaningful and applicable in a variety of real-life situations. Demos, important tools for instruction in any class format, enable instructors to engage the students on a level beyond that created by lectures. Projects are useful in helping students to apply the course material and to make connections between mathematics and the real world. This session invites papers about favorite instructional demos and course projects appropriate for any level in the undergraduate curriculum designed to engage students and to enable them to gain insight into mathematics. Presenters of demos are encouraged to give the demonstration, if time and equipment allow, and to discuss how to use it in a classroom setting. Presenters of projects are encouraged to discuss the specifics of how the project was conducted and how it was evaluated. Proposals should describe how the demo/project fits into a course, the use of technology or technology requirements, if any, and the effect of the demo/project on student attitudes toward mathematics.

MAA CP P1 Environmental Mathematics in the Classroom

Tuesday and Wednesday afternoons

Ben Fusaro*, Florida State University, Tallahassee, FL 32306-4510; (850) 644-9717; fax: (850) 644-4053; fusaro@math.fsu.edu
Marty E. Walter, University of Colorado

We invite papers that deal with all aspects of the applicability of mathematics to the environment at grade levels 12 to 15. Presentations are welcome that deal with exposition, pedagogy or modeling. Also welcome are talks about successful experiences with getting this intrinsically interdisciplinary subject into the curriculum. Please keep your titles short and descriptive.

MAA CP Q1 Innovative Outcome Assessment in Statistics Education

Tuesday afternoon

Robert del Mas*, University of Minnesota, 128 Pleasant St. SE, Minneapolis, MN 55455; (612) 625-2076; fax: (612) 625-0709; delma001@umn.edu
Carolyn Cuff, Westminster College,

Statistics education advocates innovative, interactive instruction in the classroom. Faculty report that students comprehend and enjoy statistics more, but how do we know for certain? How do we assess the learning outcomes in our courses at the level of literacy, reasoning, and statistical thinking? Beyond assessment itself, how do we use the results from assessment to inform future instruction? Faculty are invited to submit papers that describe course activities and objectives, include examples of assessment (traditional and alternative) of students that are linked to those activities and objectives, and demonstrate how information from the assessments is used to modify instruction. Papers that demonstrate the use of assessment for purposes other than examination, homework, and paper grading are encouraged and welcome.

MAA CP R1 Who Needs Algebra! Alternative Introductory Mathematics Courses
Tuesday afternoon
Judy Ackerman*, Montgomery College, 51 Mannakee Street, Rockville, MD 20850; (301) 279-5027; fax: (301) 279-5028; jackerma@mc.cc.md.us
Susan Forman, Bronx Community College
Kathie Yoder, L.A. Pierce College

Many departments, and even colleges, require all students to study "college algebra", a title that spans a wide variety of pre-calculus topics. However, such courses may not contain the most appropriate subject matter for many students, particularly those who do not plan to continue the study of mathematics. Many courses such as the history of mathematics, discrete math topics, courses linked with applied fields, introductory statistics and probability, college geometry, finite mathematics, and so on may better serve the mathematical needs of many students and/or their major departments. This session will showcase alternatives to college algebra that meet mathematics graduation requirements. We particularly welcome presentations that reflect new thinking about mathematics courses, pedagogy, delivery mode and/or utilize technology as a tool to access mathematical objectives. Presentations should address the issues of prerequisites and transferability. This session is sponsored by the Committee on Two Year Colleges (CTYC) and the Committee on Quantitative Literacy (CQL).

MAA CP S1 SIGMAA on RUME Contributed Paper Session
Tuesday and Wednesday mornings
Julie Morrisett Clark*, Hollins University, Roanoke, VA 24020; (540) 362-6595; fax: (540) 362-6629; jclark@hollins.edu

The Association for Research on Undergraduate Mathematics (ARUME) aims to foster a professional atmosphere for quality research in the teaching and learning of undergraduate mathematics. Contributed paper sessions for mathematics educators and professional mathematicians interested in research on undergraduate mathematics education. Research papers that address issues concerning the teaching and learning of undergraduate mathematics are invited. Theoretical and empirical investigations using qualitative and quantitative methodologies are appropriate. These should be set within established theoretical frameworks and should further existing work. Reports on completed studies are especially welcome.

MAA CP T1 General Contributed Paper Session
Sunday and Monday afternoons
Shawnee L. McMurran*, California State University, San Bernardino; (909) 880-7249;
fax: (909) 880-7119; mcmurran@math.csusb.edu
Emilie Kenney, Siena College
Sarah Mabrouk, Framingham State College

This session is designed for papers that do not fit into one of the other sessions. Papers may be presented on any mathematics-related topic. Papers that fit into one of the other sessions should be sent to that organizer, not to this session. Papers should not be sent to more than one organizer. E-mail submissions are preferred.

Submission Procedures for MAA Contributed Papers

Submit your abstract directly to the AMS. Concurrently, send a more detailed one-page summary of your paper directly to the organizer - indicated with an (*). The summary need not duplicate the information in the abstract. In order to enable the organizer(s) to evaluate the appropriateness of your paper, include as much detailed information as possible within the one-page limitation. Your abstract and summary must reach the AMS and the organizer by Friday, September 14, 2001.

The AMS will publish abstracts for the talks in the MAA sessions. Abstracts must be submitted on the appropriate AMS form. Electronic submission is available via the Internet or email. No knowledge of LaTeX is necessary, however, LaTeX and AMSLaTeX can be accommodated. These are the only typesetting systems that can be used if mathematics is included. To see descriptions and to view the electronic templates available, visit the abstracts submission page on the Internet at http://www.ams.org/abstracts/instructions.html, or send e-mail to: abs-submit@ams.org, typing HELP as the subject line.

Completed email templates must be sent to ABS-SUBMIT@AMS.ORG with SUBMISSION as the subject line. Abstracts submitted electronically are quickly either acknowledged, with a unique abstract number assigned to the presentation, or rejected, with a short message on what information is missing or inappropriate.

All questions concerning the submission of abstracts should be addressed to:abs-coord@ams.org.

Here are the codes you will need: MEETING NUMBER: 973

The EVENT CODE is the seven characters appearing before the title of the sessions shown below, e.g., MAA CP A1

The SUBJECT CODE is the last two-character letter/number combination from the event code list, i.e., A1, B1.

Short Takes

Radical Equations and the Algebra Project Get National Attention

Robert Moses' new book *Radical Equations*, recently published by Beacon Press, has brought renewed media attention to Moses' Algebra Project, which helps inner-city and rural students gain the skills and confidence they need to prepare for college mathematics. The book's subtitle, "Math Literacy and Civil Rights," captures the book's essential argument: that promoting mathematics literacy should be considered a civil rights issue. Robert Moses, who is a mathematician and teacher by training, was one of the leaders of the Student's Non-Violent Coordinating Committee in the 1960s. He has been working on the Algebra Project since the mid-1970s. Look for a review of Moses' book to appear soon on MAA Online.

2001 AIM Fellow Named

The American Institute of Mathematics has named Lenhard L. Ng as the recipient of the 2001 AIM Five-Year Fellowship, which includes 60 months of full-time research support. Ng, who will receive his Ph.D. from the Massachusetts Institute of Technology this June, works in differential geometry. As a high school student, he received gold medals in the 1992 and 1993 International Mathematical Olympiads. Ng did his undergraduate work at Harvard University; he was a Putnam Fellow three years in a row, and twice participated in Joe Gallian's REU program at the University of Minnesorta at Duluth. Ng has already written nine papers on a variety of topics including graph theory, knot theory, and mathematical physics.

Children See Mathematicians as Fat Nerds

According to a report published by the *Times* of London, 12- and 13-year-old children from seven countries describe and draw the "archetypal mathematicians" as "paunchy, nerdy type with virtually no social life." Some children from Finland drew pictures of mathematicians forcing children to solve equations at gunpoint. Another drawing showed a man with unshaved face, stained clothes, and dirty hair. These descriptions are the result of a study by the Centre for Teaching Mathematics at Plymouth University in England. John Berry, who directed the project commented that "Children did not have much idea of what mathematics was or what mathematicians do. We were surprised the image was fairly common in all countries, even those like Romania where math teaching is very successful."

In February, Keith Devlin dedicated his *Devlin's Angle* column on MAA Online to a discussion of the study. He pointed out that a negative image of mathematicians can have an impact on crucial choices that children and young adults make. "We need to work on our image," he concludes.

The *Times* article is available online at http://www.thetimes.co.uk/article/0,,261352,00.html. The February *Devlin's Angle* is at http://www.maa.org/devlin/devlin_2_01.html.

Office of National Drug Control Policy takes down anti-math ad

In the March FOCUS, we reported on an anti-drug advertisement in which mathematics was portrayed in a negative light. Samuel Rankin, director of the Washington office of the American Mathematical Society, acted as the spokesperson for the mathematical community. "I have spoken with Alan Levitt of the Offfice of National Drug Control Policy," he reported in an email message. He is quite embarrased by the advertisement and has agreed to take it down. He mentioned that his office actually has programs that encourage kids to take mathematics."

Tom Apostol Elected to Greek Academy

Tom M. Apostol, professor of mathematics emeritus at the California Institute of Technology and the creator and director of Project MATHEMATICS! (http://www.projectmathematics.com) has been elected a corresponding member of the Academy of Athens. Apostol, who is an American of Greek descent, becomes one of about forty foreign members of the Academy, which is named after the school first established by Greek philosopher Plato. Apostol will be officially welcomed into the Academy in Greece on May 8. In addition to his research work, Apostol is known around the world for his textbooks and, more recently, for the videos produced by Project MATHEMATICS!, most of which are distributed by the MAA.

Summer Workshop: TA and Instructor Development Through Case Studies

The Boston College Mathematics Case Studies Project will be offering a summer workshop for mathematics faculty on July 8 and 9. The workshop, which will be held on the campus of Regis College in Weston, MA, uses a case studies approach to help teachers improve their performance as instructors. The case studies to be used at the workshop are specific to university-level mathematics instruction, and have been developed by a diverse group of mathematics researchers and educators. Dormitory accommodations and meals will be provided by Boston College through a grant from FIPSE, The Fund for the Improvement of Post-Secondary Education. For more information, check the workshop web site at http://www.bc.edu/bc_org/avp/cas/math/publicprojectPI/summer-workshop-2001.html or contact Solomon Friedberg (friedber@bc.edu) or David Foster (bccase@bc.edu) at the Boston College Department of Mathematics, Chestnut Hill, MA 02467-3806.

Building Teacher Leadership in Mathematics

In collaboration with the University of Massachusetts at Lowell, the Education Development Center has developed a content-centered professional development program for mathematics teachers and department heads. The two-year program consists of two 2-week summer institutes together with work during the academic year. A major goal is for participants to develop the ability to plan and provide professional development opportunities for mathematics teachers in their home districts. EDC will organize a two-day NSF-supported institute in February 2002 focusing on the design and implementation of this professional development program. Entitled Building Teacher Leadership in Mathematics, this institute will take place in Cambridge, Massachusetts. For more information and to receive registration materials please contact the Conference Coordinator at brc@edc.org, or by mail at Education Development Center, Inc., 55 Chapel Street, Newton, MA 02458. ■

Letters to the Editor

On MAA Meetings

While attending the New Orleans meeting I realized that there are several kinds of paper sessions now besides MAA Contributed Paper Sessions. FOCUS has been only publishing the MAA sessions in its issues. My suggestion is that FOCUS publish not only MAA and AMS joint paper sessions, but also the other AMS sessions. Not every one is a member of both MAA and AMS. The other point that I would like to share with the readers of FOCUS has to do with the publication of abstracts of papers presented in MAA MathFest, as is done for the winter meetings. It is professionally important for the faculty to see something published. Otherwise, there is no distinction between a faculty who has not done anything and the one who presented a paper at MathFest. Let me remind everyone that many years ago, when the summer meetings used to be joint, abstracts were published in a volume. Maybe it is time to think of having joint summer meetings again. It used to be a lot of fun!

Satish C. Bhatnagar
University of Nevada

Jim Tattersall, MAA Associate Secretary, responds:
The issues Professor Bhatnagar raises are relevant and have been discussed in the past by various groups. One approach to the first issue would be to publish the AMS program in the October issue of FOCUS. Another would be to have a separate mailing of the Joint Mathematics Meeting program and delete it from the October issues of FOCUS and *Notices*. These as well as other options are being investigated. With regard to the second issue, it appears that printing MathFest abstracts would be a significant expense. Other ways to accomplish the same goal are under discussion. We hope to find apropos solutions to both issues in the near future.

"R U Ready?" and Primality Testing

I often teach some probability theory to computer science students, and have encountered an instance of what Renz describes. It goes like this. We would like an effective method for determining whether or not some 100-digit integer is prime. There is a probabilistic test, based on a randomly chosen key, that responds either "composite" or "likely prime." If the integer is in fact prime, the response will always be "likely prime," while if the integer is in fact composite, the response will be "composite" with probability at least 0.5 and "likely prime" with probability at most 0.5. Repeated independent tests are possible. Most written treatments of this test correctly state that the probability of a composite integer generating, say, 7 consecutive independent responses of "likely prime" is at most $0.5^7 < 0.01$. Unfortunately, most treatments seem to suggest that any integer that generates 7 consecutive independent responses of "likely prime" has a greater than 0.99 probability of actually being prime. As the article makes clear, though, such a statement is impossible to make without knowledge of the probability space from which the integer is chosen.

We can do some quick and dirty analysis if we assume that the integer is chosen from a uniform distribution over all 9×10^{99} different 100-digit numbers. Using the prime number theorem, we can estimate that approximately 3.9×10^{97} of these integers are primes, so the probability that a randomly chosen integer of this size is prime is about 0.00434. If we assume that the probability of a composite number generating the response "composite" is exactly 0.5, we can use Bayes' theorem to compute that the probability that a randomly chosen 100-digit number is prime, given that it generated 7 responses of "likely prime," is only 0.358, not 0.99. Primes are so rare among the 100-digit integers that a random integer that generates 7 responses of "likely prime" is nearly twice as likely to be a "false positive" (a composite masquerading as a prime) as it is to be an actual prime.

Paul K. Stockmeyer
College of William and Mary

Joe Buhler notes that while the basic point is correct, in practice "a typical pseudoprimality test has probability much higher than .5 on each trial, and any self-respecting primality tester will check for small prime divisors (at the worst, relative primeness to 2x3x5, and more typically all small primes up to, say, 1000), so the actual sample space is much more fully stocked with primes than is suggested."

"R U Ready?" and the Genome

I enjoyed Peter Renz's probability article in FOCUS. I am working on a "Whole Genome" problem in which two possibly overlapping pieces of the genome are considered (and this is done for each of 1012 pairs). The question is whether sequences A and B of the bases represent overlapping parts of the genome. The sequences need not correspond exactly to the genome because of transcription errors. This is like your problem of determining if the coins are fair, so I like to use the term "plausibility." How plausible is it that 10 consecutive heads would come about from a fair coin? Of course, it is possible. So I call the resulting .000977 the "plausibility." We look for pieces of the genome that plausibly overlap. Due to repeated sequences in remote parts of the genome, one could get the identical sequence and have them still come from different parts of the genome. Five heads and five tails would make it extremely "plausible" that the coin is fair, but of course it might not be. Plausibility = 1. Probability = ?

James A. Yorke
University of Maryland

Intellectual Coastalism

In the January 2001 issue of the *College Mathematics Journal*, an article by Martin Gardner depicts the mishandling of a mathematically talented minority youngster by a public school teacher. Although I am a person who registers negatively on each of the objective attributes of the offending teacher (female, Baptist, Kansan, teacher's college graduate), I was put off by this charicaturization. Given the author's distinguished background, this represents a regrettable descent into political polemics.

Could not the offending teacher have been a cleft-chinned male Catholic football coach from eastern Pennsylvania, with a physical education degree from a state university? Or a frail, balding agnostic male graduate of a proudly non-sectarian liberal arts college who lives with his mother near Puget Sound? Could not the "beacon of enlightenment" for the young student have been, say, the University of Michigan? Does the relative incidence of intellectual darkness increase in proportion to the locale's distance from salt water?

The concomitant attributes of the offending teacher as presented in the story must either be (1) the most likely ones, in Mr. Gardner's mind, or (2) be those which he sees as being most likely to evoke knowing nods on the part of the reader. Either alternative points to the fact that intellectual coastalism is alive and well.

David E. Moxness
Fremont, NE

Martin Gardner responds:
If you trace the time sequence back from my story's ending you'll see that the high school events ocurred much earlier. Actually, the story is based on my own experiences in the 1930s at Tulsa Central High. If my teacher had been, say, a Catholic football coach, it would have been a different story.

There was no black student in the class. It would have been unthinkable then for a black student to have been admitted into Tulsa's only high school. Things are of course different today, and math teachers are more enlightened, but recent studies have shown that prejudice against blacks, especially in the deep south, is still a major problem among math teachers.

Learning From TIMSS-R about U.S. Mathematics Achievement

By Margaret B. Cozzens

The TIMSS results released in 1997 and 1998 indicated that American fourth grade students performed as well in mathematics and science as those in the best performing countries in the world. However, the U.S. eighth grade students were only average, and U.S. 12th graders were close to the bottom in both mathematics and science.

Pursuing Excellence (NCES, 2000) reports results from the second installment of the Third International Mathematics and Science Study (TIMSS) – the TIMSS-Repeat (TIMSS-R) – and provides additional information about mathematics and science education in the United States. TIMSS-R was the most comprehensive international comparative study of its kind, assessing eighth-grade students in 38 countries around the world and collecting background information on students, schools, teachers, and curricula.

In a nutshell, what TIMSS-R tells us is that the U.S. eighth graders are about average in mathematics and science compared to students in other countries. U.S. students performed below students in countries such as Japan and Canada, while testing on a par with students from England and the Russian Federation (in one or the other subject) and above those in Italy – to name a few examples from among the G-8 countries that participated in the study. The U.S. results have not changed significantly since the first TIMSS study took place in 1995. The US was in the middle then, too, at the middle grades.

Thirty-seven states and districts also took part in the TIMSS-R assessment as if they were countries, with all of the sampling parameters in place. The results of this participation were announced April 4 as the Benchmarking Study for TIMSS-R. According to this report, there is tremendous variation in the mathematics and science achievement of eighth-grade students across the United States. The results provide a valuable resource to help us try to find out why there is such wide variation in the United States. The answers will most likely point towards improvement in a whole range of areas, such as teacher preparation, instructional practice, and curriculum. For many states and districts, in the midst of implementing educational reforms, participation was a bold and exposing step. The study confirms that, when it comes to educational improvement, there is no "magic bullet."

Mathematics and science achievement in the United States spans nearly the full range that is found in the world. There are some districts (often wealthier, suburban districts) in which achievement reaches levels comparable to high-performing Asian countries. However, there are other districts (often poorer, urban ones) in which average performance is on par with the lower-performing countries.

An interesting set of special case results occurred in Illinois. The Naperville School District, in suburban Chicago, and the First in the World Consortium of school districts north of Chicago performed near the top in mathematics. The state of Illinois, however, performed just above the U.S. average, and the city of Chicago's performance was near the bottom, just above Tunisia. Thus, the variations within the state mirror U.S. differences, which in turn mirror the full range of international differences.

Lessons Learned from the Achievement Data

Although one may have to wait a bit longer to see the effects of education reform reflected in international studies, there are several hopeful lessons or messages from TIMSS-R and the Benchmarking Study for mathematics. Primary among these lessons is that children learn what they are taught. In mathematics, the content areas that are taught with the most frequency are the three areas in which U.S. students outperformed their international peers: fractions and number sense, data representation, and algebra. On the other hand, U.S. students did less well in geometry and measurement, which are emphasized the least. In many ways, this is very good news: children are, in fact, learning what they are being taught. However, these results also show that curriculum matters a great deal.

One of the interesting findings from the Benchmarking Study is that there is remarkable similarity in the topic areas that are emphasized in eighth-grade mathematics classrooms in the United States. Mirroring the national averages, each participating state or district(s) placed relatively strong emphasis on numbers, data representation, and algebra and relatively weak emphasis on geometry and measurement. While the study shows that curricular emphases may be surprisingly similar, and uniformly lacking in geometry and measurement, it also suggests that there are other differences that must be understood to understand the wide range of achievement.

The Benchmarking Study also shows an apparent disconnect between emphasis on reasoning and problem solving and achievement. About half (49%) of the high achieving Japanese students had teachers who reported a high degree of emphasis on reasoning activities in their mathematics classes, more than in any other country. But the emphasis on problem solving varied dramatically across the Benchmarking participants. Both students in Jersey City, scoring towards the bottom in achievement, and students in the First in the World Consortium and the Michigan Invitational Group, scoring towards the top, had teachers who reported a significant emphasis on reasoning and problem solving.

Another bit of good news is that between TIMSS and TIMSS-R black students' performance improved significantly in mathematics. Without making light of this important finding, we also need to remember, however, that it is not enough for any one racial or ethnic group to better itself. Differences between the groups must also cease to be significant, reflecting increasing equity in students' opportunities to learn and access to qualified teachers and rigorous curriculum. TIMSS-R shows that the gap between black students and white students has narrowed but still exists.

Instructive Lessons from the TIMSS-R Contextual Data

In addition to important insights into achievement, TIMSS-R also provided information on what occurs in middle school mathematics classrooms around the country – information such as how time is spent in the classroom and what the qualifications of teachers are. Several important messages and lessons come from this data, as well. Although further analysis is needed about the relationship of these variables to achievement, their importance, even as descriptors, cannot be overstated. They provide important clues about the many factors that can enable quality learning in U.S. schools.

One of the indications from TIMSS-R is that more time could be spent on instruction in

U.S. classrooms – time that the study suggests currently is being spent on other activities. For instance, TIMSS-R results showed that U.S. students spend significantly more time on homework than the average student in the study does. Our eighth graders are much more likely than their international peers to discuss their mathematics homework in class and to begin their homework assignments as part of their regular class work. The point here is not that students are getting too much or too little homework – data on the relationship between the time students spend doing homework and their achievement is debatable. The point is that, in the United States, more classroom time is given up to activities that are intended for individual practice than in nearly every other nation that participated in the study. By moving homework back into the home, precious minutes can be gained for active instruction.

Another lesson for instructional practice may be the finding that the practices of demonstrating how to do mathematics problems and of setting students to work on worksheets and textbook exercises were much more common in the United States than they were in other countries. In other countries, students are more likely to work on project-oriented work of the type recommended by the National Council of Teachers of Mathematics in their well-known 1991 Standards. One of the concerns among people working in education today is that teaching styles in the United States still tend to focus on demonstration of ideas and individual work rather than on facilitation of rigorous learning and collaboration among students. The data suggest that progress needs to be made in this area. The TIMSS-R video study of mathematics teaching practice in the United States and six other countries hopefully will shed some additional light on this issue.

Another one of the likely factors in quality learning that TIMSS-R provides is a status report on the need for a competent, caring, and content-knowledgeable teacher in every classroom. While the U.S. has many competent and caring teachers, TIMSS-R data indicates a comparative lack in knowledge of the content area. U.S. students are less likely than their peers to have teachers who have degrees in the subject areas they teach. For instance, the TIMSS-R results showed that almost three-quarters of students in other countries have mathematics teachers with a degree in mathematics, compared to less than half of students in the United States. Instead, U.S. students were much more likely to have mathematics teachers with a general education degree. While the education community focuses on establishing and supporting high academic standards for all students, it must also encourage and provide the necessary supports for teachers to achieve those same high standards. Students deserve teachers who have a deep conceptual understanding of specific content areas, which they are in turn able to share with students in the classes they teach.

Finally, at the same time that TIMSS-R suggests (or, rather, reminds us of) the importance of qualified teachers, it also shows us that U.S. teachers have fewer opportunities for professional interaction than do their international peers. U.S. mathematics teachers spend only one class period per year, on average, observing another teacher's practice and only two to three periods being observed. Literature has long emphasized that teachers need regular opportunities to work with and learn from one another in meaningful ways.

Our Neighbors to the North

One set of findings from TIMSS-R merits a mention in our commentary and, perhaps, further exploration in secondary analyses. Although U.S. students did not show significant improvement in their mathematics performance between TIMSS and TIMSS-R, Canadian students did show significant improvement in mathematics (and science). As Canada faces some of the same issues that the U.S. faces – working within a large federal system that supports local control, and with increasingly diverse and needy student populations – there may be lessons to learn from our neighbors to the north about what factors may have accounted for their demonstrated increases. Although there clearly is no "silver bullet" or magic formula that can be picked up and copied, even from a country with which we have some things in common, it would be useful to explore the Canadian situation in more depth.

Looking toward the Future

As the new administration continues to take shape, education clearly has emerged as a key issue, one that received early attention and action from the new President. In addition to the President's plan to "Leave no Child Behind," two other legislative proposals have been put forth. These plans, with varying levels of emphasis, address the need for early literacy, accountability in schools, and strategies for helping schools at risk of failing their students. At a time when lawmakers are focusing on selecting programs and strategies and allocating funds, TIMSS-R is a reminder that curriculum, instruction, and teacher preparation are crucial pieces of this picture, worthy of immediate attention and inseparable from any other aspect of education reform. Without getting more content trained teachers into the classroom; without providing teachers with opportunities to improve pedagogical skills and perceptions of themselves as a part of a professional community; without examining what and why to teach, the U.S. will not be able to reduce existing educational disparities and meet the needs of students who, when given the opportunity, can learn as well as any other students in the world.

It is also abundantly clear that the mathematical organizations in the U.S. need to consider seriously their role in K-12 mathematics education, particularly the education of teachers. This is not simply the responsibility of NCTM. It is also clear that simply changing the pedagogical approaches to teaching mathematics to more problem-centered instruction is not sufficient without rigorous content. Everyone will once again have to seriously address education in urban schools where even the infrastructure is not sufficient for quality learning to take place. Why would the best and the brightest want to teach in schools where the toilets don't work and the roof leaks? Can we leave urban children behind while the rest of the country becomes educated?

For more details and sample problems from the Mathematics TIMSS-R Study please see the NCES web page at http://nces.ed.gov/TIMSS/TIMSS-R/highlights.asp and for the Benchmarking Study at http://isc.bc.edu or http:/nces.ed.gov/TIMSS/TIMSS-R/benchmark.asp.

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