FOCUS is published by the Mathematical Association of America in January, February, March, April, May/June, August/September, October, November, and December.

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Periodicals postage paid at Washington, DC and additional mailing offices. **Postmaster:** Send address changes to FOCUS, Mathematical Association of America, P.O. Box 90973, Washington, DC 20090-0973.

ISSN: 0731-2040; Printed in the United States of America.

FOCUS

Volume 25 Issue 8

Inside

On the cover: The MAA tour group contemplates the Temple of the Inscriptions in Palenque, Mexico. Photograph by Lisa Kolbe. See article on page 13.

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Employment Ads	November 11	December 9	January 15

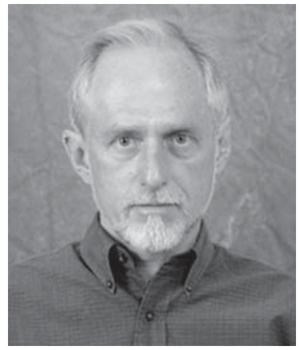
Dewar, Stroyan, and Walker Receive Haimo Awards

By Fernando Q. Gouvêa and the Haimo Committee

Jacqueline Dewar, Keith Stroyan, and Judy Leavitt Walker are this year's recipients of the MAA's most prestigious award for teaching, the Deborah and Franklin Tepper Haimo Award for Distinguished College or University Teaching of Mathematics. They will receive their awards at the Joint Mathematics Meetings, where they have also been invited to speak about "the secrets of their success." These presentations will happen on Saturday, January 14, from 2:30 to 4:00 p.m.


Judy Leavitt Walker


Jacqueline Dewar


Keith Stroyan

During Jacqueline Dewar's almost 32 years at Loyola Marymount University in Los Angeles, "her enthusiasm, extraordinary energy, and clarity of thought have left a deep imprint on students, colleagues, her campus, and a much larger mathematical community." (Here and below, quotations are from the award citation.) Dewar has been deeply involved in teacher education initiatives and research on mathematics teaching and learning. She has put new ideas into practice with great success. At LMU she has introduced several "laboratory" courses, ranging from *Mathematics for Elementary Teachers* to a workshop course for first-year mathematics majors that helps introduce students to mathematics. Dewar is now involved in a new project called *Science Education for New Civic Engagements and Responsibilities*.

Dewar's talk at the Joint Meetings, *Mathematics is ———*, will take definitions of mathematics given by laypersons and experts, and move on to examine the differences between them. Dewar will discuss why and how we should attempt to make students' views agree a little better with those of the "experts," and describe an attempt to do this in a course for future teachers.

Keith Stroyan has taught at the University of Iowa for over 30 years. He was a pioneer in the introduction of technology and computers into calculus courses, but he does not use these tools merely to draw pretty pictures or to allow students to avoid learning to compute. Instead, he focuses on a concrete, experiential approach, "using computer projects to engage teams of students in investigating concrete applications of mathematics." One of his projects, for example, asks students to investigate the question: "Why did we eradicate polio by vaccination, but not measles?" Since he uses teaching assistants in this course, Stroyan has also trained many graduate and undergraduate students in this style of teaching. Stroyan was deeply involved in the "calculus reform" movement, received grants to develop materials, and wrote textbooks, all of which emphasize the role of mathematics as "the language of science."

Stroyan's talk at the Joint Meetings is called *Small Opportunities at a Big University*, and will focus on teaching elementary courses at a large research university. His abstract notes that "there are many disadvantages teaching elementary courses at our university." As a state university, the University of Iowa has a responsibility to serve students with a wide spectrum of backgrounds, abilities, and goals. Stroyan will describe how these and other opportunities play a role in his new Calculus 2 course, *Engineering Math 2*.

Judy Walker joined the faculty at the University of Nebraska–Lincoln in 1996; and has already had significant impact on both her institution and the larger mathematical community. Students "testify that her courses are among the most demanding they ever had, yet consistently praise her ability to guide the direction of a class through questions." She created a first-year seminar for non-majors, *The Joy of Numbers: Search for Big Primes*. Walker has also been deeply involved in the ALL GIRLS/ALL MATH program, has worked with undergraduate women mathematics students, and is currently working on a project focused on mentoring graduate students through critical transitions.

At the Joint Meetings, Walker will speak on *The Joy of Teaching The Joy of Numbers*, which she describes as "one of my favorite courses to teach." Her abstract says that "though all the students in this course are honors students, they are not necessarily mathematically inclined. And yet these students, some of whom cringe at elementary algebra, learn to write proofs as they work their way from the definition of what it means for one integer to divide another, through card shuffling and identification numbers, to the RSA scheme for public key cryptography."

The Mathematical Association of America first instituted Awards for Distinguished College or University Teaching of Mathematics in 1991, with the goal of honoring college or university teachers who have been widely recognized as extraordinarily successful and whose teaching effectiveness has been shown to have had influence beyond their own institutions. In 1993 the MAA Board of Governors renamed the award to honor Deborah and Franklin Tepper Haimo.

Don Albers Will Step Down as Director of Publications

By Gerald L. Alexanderson

No one is indispensable, we are told. One exception might be Don Albers in his role as acquisitions editor for the various book series of the MAA. The question arose recently when Don informed Executive Director Tina Straley that he will be serving out his current term as Associate Executive Director and Director of Publications but will not be available for another. Needless to say this prompted some quick thinking on the part of Officers and the Executive Director.

Friends of Don and his wife, Geri, have long known that Don and Geri were awaiting the day when they could move back to their California home. Both having been raised in the Minnesota-North Dakota area, perhaps more than some they have an appreciation for the Northern California climate. Combining this with a shared love of hiking and camping in the Western mountains made the decision inevitable. It was only a question of when and some of us were surprised the decision had not come before now.

Fortunately the current plan is to replace Don as Director of Publications with someone who could take on overseeing the publications program in the Washington headquarters, and to convince him to continue as Acquisitions Editor from his new base in California, something that should be easily possible in this age of electronic communication. Don has built the publications program to the point where having an Acquisitions Editor working with the Director of Publications is essential.

It is difficult to imagine our finding someone to replace him in this latter role who would have his experience, his track record, his knowledge of the wide mathematical community, and his extraordinary ability to wheedle manuscripts out of potential authors who otherwise might not have thought about writing a book. Never content to wait for manuscripts to come in through the mail, Don gets an idea for a book and goes out and finds a suitable person to produce it. Under Don's stewardship, MAA book sales have quadrupled since 1991, bringing in $1.6 million last year. Instead of the occasional Carus Monograph that some of us remember as the MAA's book program, roughly twenty new books now appear every year.

Don Albers

As hard as it is to believe at this point, Don did not start out life as an editor and administrator. Born, raised and educated in those cold states in the Northern tier of the country, he came to California in 1968 and joined the faculty of Menlo College, where he served as department chair for 21 years. Don and I met at that time through our having a mutual friend, George Pólya. While at Menlo Don built a superb department of teachers and scholars, a group now sadly dispersed as the result of a decision by the administration there to take the College in a different direction. While at Menlo, though, Don became involved with the MAA as a member of various committees, Chair and later Section Governor of the Northern California Section, Second Vice President, and Editor of the (then) *Two-Year College Mathematics Journal*. When Don became editor, he changed and broadened the publication so much that by the end of his term as editor in 1984 the words "Two-Year" were dropped from the title. He imaginatively introduced all sorts of new features to the *Journal*—in his first issue, an interview with Pólya, a column called "The Lighter Side," a section on "Mathematical Gems" by Ross A. Honsberger, "Classics Revisited," "The Signpost: News & Commentary," as well as some unusually lively and witty covers. These were precursors of things to come — and the MAA publications would never be quite the same.

Don not only acquires good material for the MAA publications program, he has published widely himself. He had the idea for the interviews that were a staple in the *CMJ* for years and became the core of two volumes of the *Mathematical People* series, an idea now emulated in various publications including the *Notices of the AMS*. He continues to do interviews, the most recent that with Tina Straley in the September 2005 issue of FOCUS.

Don arrived at the MAA headquarters in 1991 with the title Director of Publications and Programs, overseeing journal publications in addition to the book series, electronic publishing, book production, sales and marketing of publications. His Programs responsibilities included the Placement Tests Program, Student Chapters, Career Information, and MAA Reps. Two years later as technology changed so did his title to Director of Publications and Electronic Services. In that new role he supervised development of MAA Online. Over the years Don also has served as the principal investigator on grants related to electronic services and acting as liaison with the Dolciani-Halloran Foundation in their support for Project NExT, with the Educational Advancement Foundation on the American Archives of Mathematics, and with JSTOR. During periods of transition in the Washington office he has taken on additional tasks. He also introduced four new book series (Spectrum, Classroom Resource Materials, Outlooks, and the MAA Problem Books) and was the founding editor of *Math Horizons* for students. Forming such a student magazine was Don's idea and the magazine has been highly successful.

Probably what he enjoys most, though, is finding good manuscripts. And he knows a good one when he sees one—he seemingly reads everything he can get his hands on. He's always well ahead of most of us in keeping up on what has appeared from just about any English language publisher and many that are in other languages as well. Not satisfied with staying abreast of what's happening in mathematics, he regularly returns to his longtime interest in astronomy, and other sciences as well. And then there are the nonscientific fields. I would not like to be paying the bill for shipping his vast collection of books in Washington when they have to be sent to join his library still in California. Perhaps we should think of his move as a consolidation of libraries.

The MAA is lucky indeed that arrangements have been worked out to keep this man of letters at the MAA to continue his role as Acquisitions Editor. We can look forward to many new and worthwhile books that will be appearing in the MAA catalogue in the years ahead.

Gerald Alexanderson is Professor of Mathematics at Santa Clara University and former president of the MAA.

Note from the Editor

Readers will have noticed that this issue of FOCUS is a little heftier than usual. This is due to the inclusion of a special report on the MAA's SAUM program. This special report, edited by Bernard L. Madison and Lynn A. Steen, begins on page 34 of this issue.

We are always looking for contributions to FOCUS. At this point, we are particularly interested in more articles about *mathematics*, either expository or reflective. But of course, we are also interested in news: about mathematics, about mathematics teaching, about MAA activities. See the guidelines on how to write and submit articles for FOCUS online at:http://www.maa.org/pubs/focussubmission.html.

University of Nebraska Lincoln

Eighth Annual

Nebraska Conference for
Undergraduate Women
in Mathematics

February 3 - 5, 2006
A national showcase for research projects of undergraduate women in the mathematical sciences.

Main Program
Talks by undergraduate women about their own research

Plenary Speakers
Lenore Blum,
Carnegie Mellon University

Krystyna Kuperberg,
Auburn University

For undergraduate participants, most local expenses are covered and travel support is available.
For more information, to register,
apply for funding, or sign up to give a talk,
visit us on the web at

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University of Nebraska-Lincoln
203 Avery Hall
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Deadline for registration
January 20, 2006

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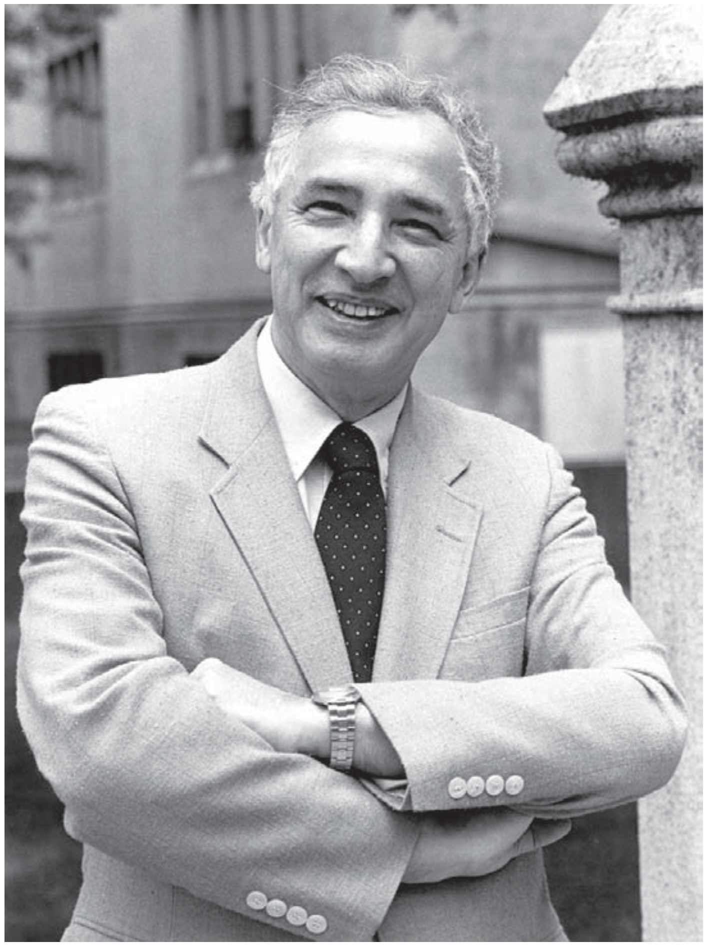
Archives of American Mathematics Spotlight
The Walter Feit Papers

By Nikki Thomas

The Archives of American Mathematics at the Center for American History has recently processed the papers of Austrian-born mathematician Walter Feit, a pure mathematician who contributed to algebra, geometry, topology, number theory, and logic and who co-authored one of the most influential papers ever written on finite group theory. Sidnie Feit, Walter's widow, donated the papers and provided a detailed initial inventory.



Walter Feit, 1988. From the Walter Feit Papers, Archives of American Mathematics, Center for American History, The University of Texas at Austin.

Feit was born in Vienna in 1930. At the age of nine, Feit's parents placed him on the last KinderTransport train allowed to evacuate Jewish children from Austria. The train left just two days before the war broke out in 1939. Feit attended high school in England and became passionate about mathematics. In 1946, he left England for Florida and lived with his aunt and uncle. The fall after his arrival in the United States, Feit entered the University of Chicago, and earned both his Bachelor's and Master's degrees in 1951. In 1955, he received his Ph.D. from the University of Michigan under the supervision of Robert Thrall, although Richard Brauer was Feit's true mentor.

Feit began his career in mathematics in 1953, joining the mathematics faculty at Cornell. There he worked on his 1963 paper with John G. Thompson, "Solvability of Groups of Odd Order," which is widely regarded as the most influential paper ever written on finite group theory. In 1964 Feit made the move to Yale where he remained for 40 years until his retirement in 2003. While his most famous result is the proof of the Feit-Thompson theorem, he wrote and published extensively over the years, working in finite group theory and modular character theory. Feit passed away in 2004.

Walter Feit was awarded the Cole Prize by the American Mathematical Society in 1965 for his work with Thompson and was elected to the National Academy of Sciences and the American Academy of Arts and Sciences. He also served as Vice-President of the International Mathematical Union and editor for several journals, including 15 years as managing editor for the *Journal of Algebra*. His sixtieth and sixty-fifth birthdays were celebrated with conferences in his honor, as was his retirement in 2003.

A digital version of Walter Feit's Memorial Service, including many photographs and information about his life, can be found online at the URL: http://www.math.yale.edu/public_html/WalterFeit/WalterFeit.html.

The Walter Feit Papers consist of correspondence and other printed material, including preprints, reprints, and manuscripts. The collection contains a wealth of correspondence between Feit and John G. Thompson, primarily mathematical in nature, but also covering more personal topics. Papers, preprints, and reprints comprise a substantial part of the collection, although most reprints are included in duplicate, when available.

Dear Walter,

I was unable to get my third batch (Further Character Relations, III) run off today, so I am sending what I did get done to you.

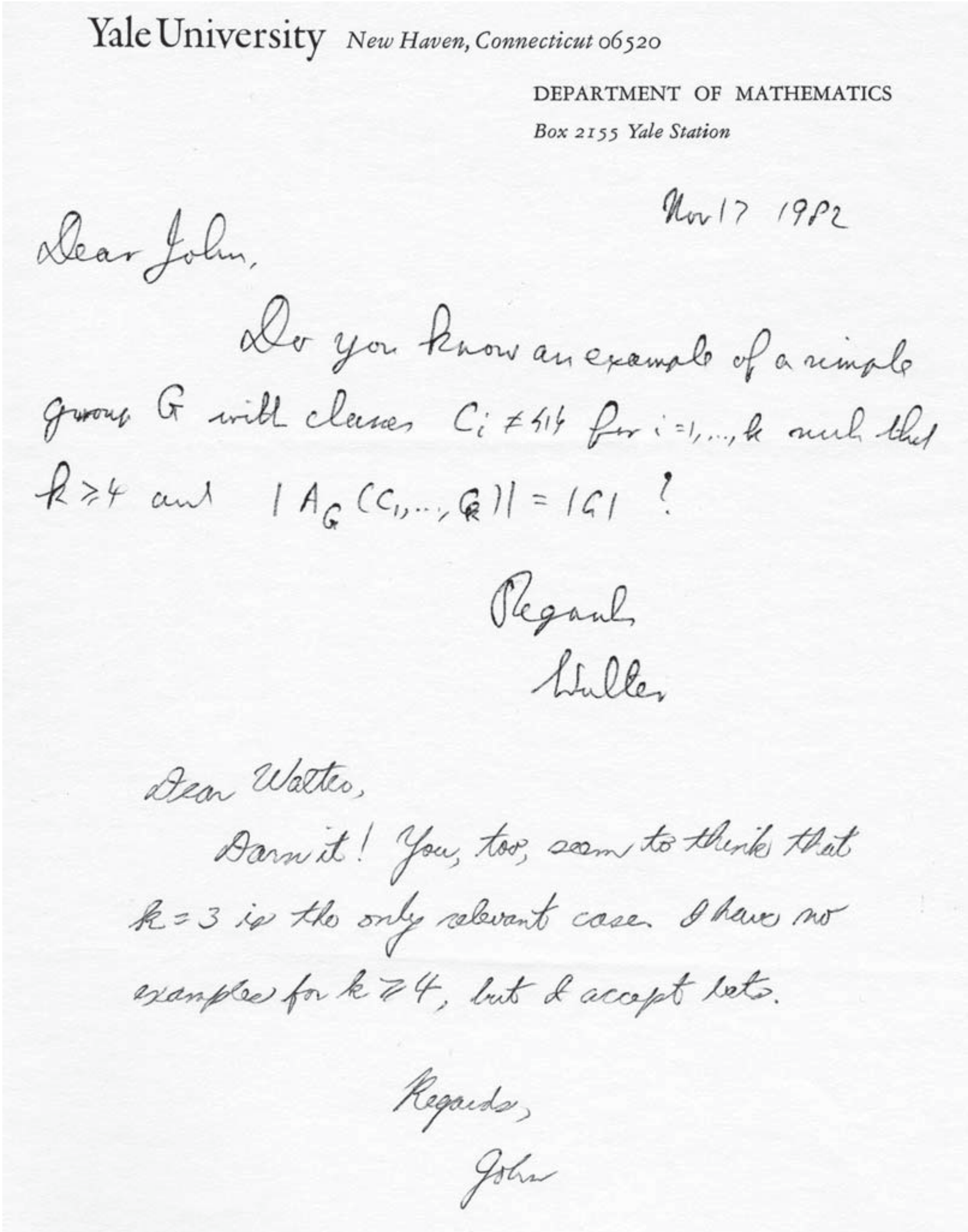
You will see how crude and yet how powerful the inequalities are. However, I made at least one mistake. Namely, the inequality immediately preceding inequality (B) holds if $p \geq 200$ but does not hold for $p \leq 100$. As you get into the proof, you will see that this is not serious. It can be gotten around by replacing the "8" in (B) by a "9" and replacing the "7" of the next lemma by an "8". I was so generous in the later inequalities that the change from a "7" to a "8" will not invalidate anything.

I hope there are no other gaps. Please forgive the abominable notation, which is like shifting sands. We must adopt a uniform scheme for notation, and I vote for Brauer's. Also, is it a good idea to use capital Greek letters for the irreducible characters of G, small Greek letters for characters of subgroups? In a paper the length of the one we are cooking up, notation is definitely non-trivial.

Best regards,

John.

Early correspondence from J. G. Thompson to Walter Feit regarding their cooperative paper "Solvability of Groups of Odd Order," ca. 1960. From the Walter Feit Papers, Archives of American Mathematics, Center for American History, The University of Texas at Austin.



Yale University New Haven, Connecticut 06520

DEPARTMENT OF MATHEMATICS

Box 2155 Yale Station

Nov 17 1982

Dear John,

Do you know an example of a simple group G with classes $C_i \neq \{1\}$ for $i=1,\dots,k$ such that $k \geq 4$ and $|A_G(C_1,\dots,C_k)| = |G|$?

Regards,

Walter

Dear Walter,

Darn it! You, too, seem to think that $k=3$ is the only relevant case. I have no examples for $k \geq 4$, but I accept bets.

Regards,

John

Informal note between Walter Feit and John G. Thompson demonstrating their continued friendship well after the Feit-Thompson theorem was published, November 17, 1982. From the Walter Feit Papers, Archives of American Mathematics, Center for American History, The University of Texas at Austin.

Of particular biographical relevance are the materials related to Walter Feit's memorial service, as they include memoirs of his life in Vienna and England.

The finding aid for the Walter Feit Papers is available online at: http://www.lib.utexas.edu/taro/utcah/00433/cah-00433.html.

The Archives of American Mathematics is located at the Research and Collections division of the Center for American History on the University of Texas at Austin campus. Persons interested in conducting research or donating materials or who have general questions about the Archives of American Mathematics should contact Kristy Sorensen, Archivist, k.sorensen@mail.utexas.edu, (512) 495-4539. The Archives web page can be found at: http://www.cah.utexas.edu/collectioncomponents/math.html.

MAA and AMATYC Welcome 2005-06 Project ACCCESS Fellows

Project ACCCESS (Advancing Community College Careers: Education, Scholarship, and Service) has recently chosen 32 two-year college faculty as Fellows for the 2005-06 academic year. Project ACCCESS is a joint project of MAA and AMATYC (American Mathematical Association of Two-Year Colleges) for the mentoring and professional development of new two-year college mathematics faculty. Funding for the project comes from the ExxonMobil Foundation. With the majority of lower-division mathematics students enrolled at two-year colleges, it is only natural that the two professional organizations find ways to work together.

The first group of 28 ACCCESS Fellows will complete their official year as Fellows at the AMATYC Conference in San Diego in November. Here, they will be joined by the new Fellows. Both groups will participate in workshops and discussions relating to their teaching and other professional commitments. Topics to be addressed this year include creating active classrooms, assessment, demographics of two-year colleges, and classroom research. Also, at the San Diego meeting, the 2004-05 Fellows will report on individual projects they carried out this past academic year at their home institutions. Fellows have created new course materials, evaluated innovative pedagogy, and conducted research on placement and assessment methods.

An important feature of Project ACCCESS is Fellows' attendance at an MAA Section meeting. One goal for the project is that Fellows become active members of both MAA and AMATYC. Sections with a Section NExT program are asked to include ACCCESS Fellows in these activities. Fellows were overwhelmingly positive about their experiences at section meetings during this past year, but indicated that they would like to see more talks or sessions focused on the first two years of the undergraduate curriculum.

Not every Section has an ACCCESS Fellow in these first two cohorts, but the project funding includes money for the creation or support of a Section NExT as well as for other types of Section-based activities for two-year college faculty. Information about applying for funding can be found at: http://www.maa.org/projectacccess. Also at the website is a complete list of both the 2004-05 and 2005-06 ACCCESS Fellows.

2006 MAA TENSOR Grants for Women and Mathematics Projects

The MAA plans to award grants for projects designed to encourage college and university women or high school and middle school girls to study mathematics. The Tensor Foundation, working through the MAA, is soliciting college, university, and secondary mathematics faculty (in conjunction with college or university faculty) and their departments and institutions to submit proposals.

Grants will be up to $5,000 and will be made to the institution of the project director to be spent within the year. College and university mathematics faculty, or secondary school or middle school mathematics faculty working in conjunction with college or university faculty, are eligible for TENSOR grants. Proposals will be due in early February, 2006. Complete details are available through the MAA website at http://www.maa.org/projects/tensor_solic.html.

Launchings from the *CUPM Curriculum Guide*

A series of monthly columns by David Bressoud now discusses the first six recommendations from this set of guidelines for the undergraduate curriculum:

Introduction **(February)**
I. **Who are we teaching?** **(March)**
II. **Teaching Students to Think** (April)
III. **Only Connect!** **(May)**
IV. **Math & Bio 2010** **(June)**
V. **Computational Science in the Mathematics Curriculum** **(July)**
VI. **On sustaining curricular innovation and renewal** **(August)**

Find the latest column at http://www.maa.org. All columns are archived at http://www.maa.org/news/launchings.html.

Change in MAA Bylaws to be Voted on at January Meeting

At the MAA MathFest in Albuquerque, the MAA Board of Governors approved a proposal to a change in the MAA Bylaws. This change will be voted on at the next Business Meeting of the Association, which will be held in January 2006 at the Joint Mathematics Meetings in San Antonio, TX. It appears here in accordance with the rules governing changes in the Bylaws, which are contained in the current MAA Bylaws, Article XI — Amendments to the Articles of the Association and Bylaws. The change affects Article VI, Section 2; which currently simply says:

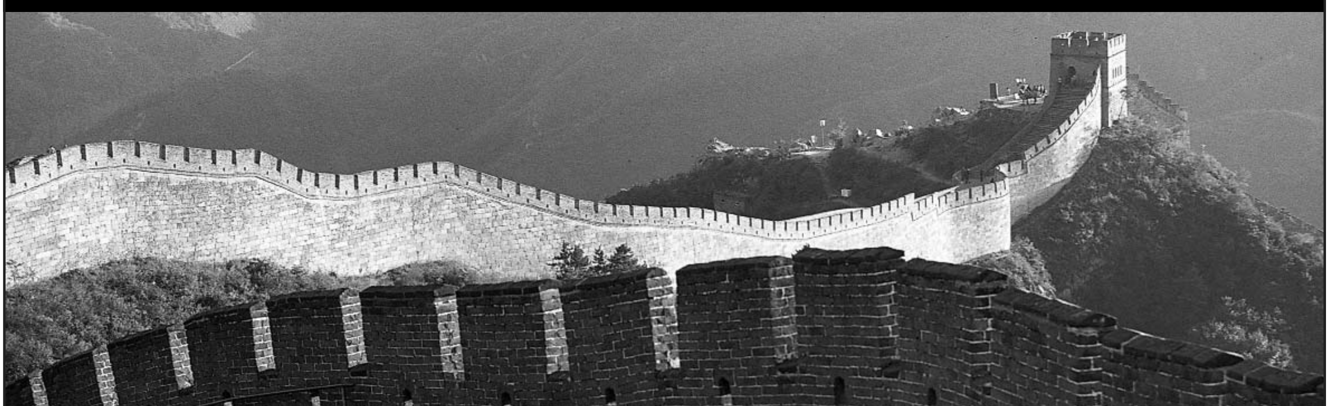
VI.2. Each member of the Association residing in the United States, Canada or their possessions shall belong to one and only one Section.

It is proposed that this shall be changed to read as follows:

VI.2. Each member of the Association residing in the United States, its possessions, or Canada, shall belong to one and only one section. A member shall belong to the section determined by his or her MAA mailing address unless he or she has been reassigned after requesting that the national office grant membership in another section.

The full text of the MAA Bylaws can be found online at http://www.maa.org (choose the "About the MAA" drop-down menu). All members are encouraged to attend the Business Meeting at the January Joint Meetings in San Antonio to discuss and vote on this amendment.

the MAA's **4th Annual** Mathematical Study Tour



Journey to CHINA

June 6 - June 21, 2006

Travel to the Land of Cathay and
Explore Its Ancient and Modern Culture

Contact Information:
Lisa Kolbe
Development Manager
lkolbe@maa.org
202-293-1170

Full details, itinerary, and registration form will be available September 1, 2005 on MAA Online www.maa.org

The Land of the Maya

By Jacqueline Dewar

The MAA Study Tour to the Land of the Maya began on May 24, 2005 with a double-decker bus tour of the sites and neighborhoods of Merida, followed by free time for lunch and shopping. Later in the afternoon our guides Chris, Alfonso, and Alonso, archeologists with connections to the Maya Exploration Center, presented talks about Mayan history and geometry. We were intrigued to hear that traditional building methods still employed by indigenous peoples of Yucatan and Chiapas today seem to support archeologists' measurements and claims that the Mayan's sacred geometry employed ratios of 1 to $\sqrt{1}, \sqrt{2}, \sqrt{3}, \sqrt{4}, \sqrt{5},$ and ϕ in their building designs. Then we turned to Mayan numeration, examining, *with manipulatives*, plausible algorithms for the arithmetic operations with their numerals. Later in the trip lectures examined the mathematics of the Maya calendars and aspects of archaeo-astronomy.

Jacqueline Dewar at Uxmal.

The next day, May 25, the physical challenge began as we bussed a short distance to Chichen Itza, a site that dates to the 7th century. A path leading through a small scrub forest suddenly opened to reveal an imposing view of our first pyramid, "El Castillo," looming in the distance. The 91 steps of this square-based pyramid rise approximately 79 ft. to a splendid view of the amazingly flat Yucatan horizon. (Such a horizon is ideal for observing various astronomical events.) Following a careful descent aided only by a rope stretched down the center of the stairway, we queued up to climb 61 slimy steps inside the pyramid single file to view an older inner temple containing a jaguar throne. It was common practice among the Mayans to build over earlier structures.

After a stroll through the ball court we arrived at the Group of a Thousand Columns adjacent to the Temple of the Warriors precisely at noon (well actually 1 PM because daylight savings time is observed in Mexico) on the day of the zenith at that latitude! Thus we were able to experience and photograph an event that never happens in the continental United States: the sun was directly overhead — objects cast no shadow. At that very moment little thermometers dangling from two of our group members' backpacks recorded the temperature as 105 degrees.

Our group of 26 quickly bonded as we helped and encouraged one another to negotiate the uneven, large, and steeply inclined stairs at the various sites. Some of us were challenged by fear of heights, others by claustrophobia, and all by the heat. But we all triumphed! Over the next 10 days we visited sites at Dzbilchaltun, Uxmal, Labna, Edzna, Bonampak, and Palenque (where the photo on the cover of this issue was taken), accompanied by our marvelous guides who enthusiastically shared their knowledge and passion for the history and culture of the Mayas past and present. Indeed, they were responsible for a major find at Palenque just a few years before.

Among the other amazing sights and experiences afforded by the trip were waiters and waitresses dancing while balancing bottles of beer on their heads, iguanas taking on various camouflage hues according to their background, dung beetles working cooperatively in pairs to move balls of you-know-what along the sacbe (raised roadbeds of ground limestone), bats hanging above us in Lolton cave, delicious food and Mexican beers and ice cream, impressive cenotes which are water-filled limestone sinkholes that provided a stable supply of water for the ancient Maya people, a chance to splash in the Gulf of Mexico, many opportunities to purchase various souvenirs, a wonderful picnic and waterfall with an icy pool for swimming at Golondrinas, and Olmec stone sculptures at La Venta park. Conversations on our bus rides revolved around celestial events, the vagaries of the motion of the shadow of a gnomon at various latitudes, and how we might incorporate what we had learned in our courses. As with the previous two MAA Study Tours, wonderful Lisa Kolbe expertly facilitated the various details and arrangements.

A number of us departed from Villahermosa on the same plane for various connections in Houston. The cover story on airplane travel magazine was titled "Beijing Beckons." A startling and pleasing coincidence: the destination for the 2006 MAA Study is none other than China.

Jacqueline Dewar is Chair of the Department of Mathematics at Loyola Marymount University in Los Angeles, California, and one of the recipients of this year's Haimo Awards.

MAA Features Dickinson College Workshop Mathematics Project at CNSF Exhibit

MAA joined mathematical, scientific, and engineering societies and universities across the country in the Coalition for National Science Funding (CNSF) 11th annual Science at Work exhibition on May 10–11 in the Rayburn Building, the large House of Representatives Office Building on Capital Hill . The purpose of the event is to exhibit to members of Congress and their staff the beneficial programs that the National Science Foundation supports. Each year, the MAA hosts a project funded by NSF that fits the mission of MAA. During the day of the exhibit, the exhibitors visit the offices of members of their state's Congressional delegations. The program takes place at 5 PM to 7:30 PM, after normal work hours. A good number of the staffers and some of the Congressmen from both the House and the Senate stop by the exhibition and reception.We asked the three visitors to share their reactions to the experience.

Nancy Baxter Hastings

I was excited and honored when Tina asked me to spend a day with her "on the Hill," talking to congressional representatives and staffers about the impact of NSF funding in general on undergraduate mathematics education and in particular on Dickinson College's Workshop Mathematics Project. Tina suggested that I bring along some students who were familiar with the project, so I invited Jeff Goldsmith '07 from Texas, and Carley Moore '06 from Pennsylvania, who had worked with me as TAs in Workshop Calculus.

Jeff Goldsmith, Nancy Baxter Hastings, and Carley Moore in front of the CNSF exhibit.

In preparation for the big day, Joanne Weissman, who has served as the Workshop Mathematics project manager for the last twelve years, and I worked with our public relations office to design a spiffy, professional-looking poster and color-coordinated brochure, and we filled small glass jars that had the Dickinson seal on the front with Hershey Chocolate Kisses (a PA delicacy) to leave as thank-you gifts.

We were all … well, maybe not Tina … a little nervous at first, but we quickly settled down into a routine. Tina introduced us and talked about the value of NSF funding. I think many of the people to whom we spoke were expecting Tina to say, "We need more!" Instead she thanked them for supporting funding in the past and emphasized the value of funding undergraduate education. I went on to mention two major impacts that NSF funding has had on Dickinson College, namely providing students with access to state-of-the-art research equipment and supporting the development of innovative curricular materials that support student learning. The main focus, however, was on the students, Jeff and Carley. They spoke enthusiastically and articulately about their experiences and observations in the workshop classroom. When we met with Rep. Ralph Hall (R-TX), who represents Jeff's district, Jeff and Carley sat in over-sized, blue leather wing chairs in front of the

Carley Moore, a Congressional staffer, Jeff Goldsmith, and Nancy Baxter Hastings

Nancy Baxter Hastings, Carley Moore, Abigail Wilson, and Jeff Goldsmith.

congressman's desk and chatted amicably with him about the importance of getting a good education, while Tina and I contributed to the conversation from a comfy sofa off to the side. When Sen. Rick Santorum (R-PA) stopped to chat with us in his outer office, he greeted us warmly, asked Tina about our visit, and then turned his attention to the students.

Jeff Goldsmith outside an office in the Rayburn Building.

Jeff Goldsmith speaks with a Congresssional aide at the CNSF reception.

At the end of each meeting, we would leave our mementos — a Dickinson candy jar and a MAA stress ball (or two) — and then scurry, some times through the tunnels connecting the congressional buildings, to our next appointment.

The day culminated with a gala reception for congressional representatives and their staffers. We talked to folks who dropped by, we posed for pictures, we nibbled on hors d'oeuvres, and then the four of us collapsed in a cab and headed back to MAA Headquarters. It had been a terrific day. We could not have been more pleased with how things had gone, but we were all too tired to talk, so we rode in silence enjoying the drive through downtown Washington and the end of a gorgeous day in D.C.

Jeff Goldsmith

My trip to D.C. for the CNSF exhibit was a great experience. I'd been to Washington before, but only to do sight-seeing, so this was a great opportunity for me to take part in the more business-oriented aspects of both mathematics and government funding. Professor Hastings, Carley Moore and I had almost no idea what we were getting ourselves into, but after a couple of meetings and the help of Tina Straley from the MAA, everyone found a comfortable flow.

We started the day with only two meetings, but thanks to the hard work of Kimberly Niono, we soon had a very busy afternoon ahead of us. I was particularly happy to meet with Ralph Hall, the congressional representative from my home district. He was very interested in how funding for the NSF had helped Professor Hastings' project, and how her project in turn affected students at Dickinson College.

I was very fortunate to have this opportunity to learn how funding for programs like the NSF is handled by the government. I also now have a deep appreciation for the hard work that goes into securing funds for the NSF and other programs that have a huge impact on the lives of many people.

Carley Moore

My trip to Washington, D.C. for the CNSF exhibit was definitely a once in a lifetime opportunity. Before this trip, my knowledge of the inner workings of the US government was limited to what I learned from my 5th grade American Government class and episodes of the "West Wing." This experience not only introduced me to a side of DC rarely seen by average tourists, but it also gave me a greater appreciation for the role of government funding for science research and the unique ability I have, as an American, to voice my support of this funding.

In the beginning, I was not sure what I was getting myself into, but I was still thoroughly honored to be asked to attend with Professor Hastings and another Dickinson student, Jeff Goldsmith. Despite being excited and nervous about what the day would hold, I was eager to share my perspective of the MAA-funded Workshop Mathematics Project at Dickinson College. The whole day turned out to be one pleasant surprise after another. At the start of the day, Professor Hastings, Jeff, Tina Straley, and myself had two appointments (less than I had expected, though I was ready to do my best at these meetings). By the end of the day we had visited with representatives from the offices of four senators and two congressmen! While that in and of itself would have been considered a highly productive day, we also had the excellent opportunity to meet and speak with both Senator Santorum and Congressmen Ralph Hall in person, both of whom were very receptive to what we shared.

That evening at the reception, I was amazed to see the number of people that turned out to see all the exhibits. It was a great feeling to have a steady stream of visitors coming to our table and asking real questions about the project. I am so glad that I have had this unique opportunity, and I know that because of it, I have a new desire to learn more about how my government works and what my role is within it.

Bob Witte, Champion of Project NExT, Dies

Robert F. (Bob) Witte, age 66, a great friend of the MAA died October 3, 2005, following complications related to cancer. Bob was born in Lowden, Iowa, and graduated with a mechanical engineering degree from Iowa State University, where he met his wife Pat, and subsequently received an MBA from the Harvard Business School. He also served as a Captain in the United States Air Force.

During his nearly 40-year career with Exxon Corporation, he spent 22 years in Houston and Baytown, where their children grew up. He transferred to Dallas in 1992 as Senior Program Officer of The Exxon Education Foundation (EEF, now the ExxonMobil Foundation) until his retirement in 2000.

While Witte was Senior Program Officer, EEF's support extended over several MAA programs and activities: *Math Horizons*, SUMMA, the Student Chapters program, publication and dissemination of *A Call for Change*, and the Distinguished Teaching Awards. His personal commitment and drive to improve mathematics education continued once he retired. He served on numerous boards and committees dedicated to this important objective.

One of the projects that Bob helped to develop and nurture is Project NExT (New Experiences in Teaching), a program for new faculty. Project NExT is now in its twelfth year, and counts more than 800 Fellows to its credit. To say that he was enthusiastic about Project NExT would be an understatement.

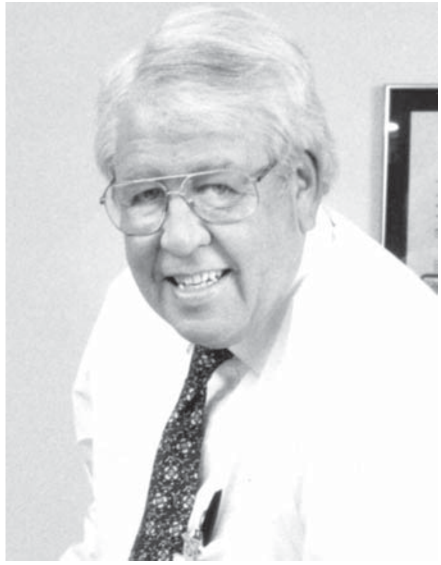
In Bob's Leitzel Lecture at MathFest 2001, *What I Have Learned from the Mathematics Community,* he made clear his feelings about NExT when he said: "NExT is not just a new technique, a new curriculum, a new insight from research, although such resources are important. NExT demands sustaining the courage to question the status quo and the willingness to change the ways in which you fulfill, indeed, live out, your responsibilities. And in the most crucial ways NExT is the network you have created, the powerfully supporting network of fellows, mentor consultants, leaders, and directors."

In his lecture, he offered the mathematics community a challenging list of tasks for the improvement of education, laced with such wry observations as *Witte's First Law of Productivity*, which states that "If you work on the wrong thing, no matter how hard you work, you will never get the right answer."

From 1994 until his retirement in 2000, he keenly observed the progress of Project NExT. Fellows from those years remember the enthusiasm with which Bob participated in workshop sessions and the eagerness with which he conversed with them about their activities and aspirations. Without making himself the center of attention, he was always a vital and welcome presence at Project NExT events.

According to Professor Christine Stevens of St. Louis University, Director of Project NExT, "Even after his retirement, Bob remained deeply interested in Project NExT. He continued to read the messages on the Project NExT listserv, and, from time to time, he would send me a message. Sometimes it would be an observation about an issue in mathematics education, and sometimes it would announce the birth of a new grandchild. Often he would comment on some Fellow's contribution to the list and then add a comment like this: "I am sure he is a wonderful teacher. Makes me wish I could be in his class. Bob truly believed that the Fellows could change the face of mathematics education."

Bob's family was fully aware of his commitment to Project NExT, and asks that in lieu of flowers memorial donations in his honor be used to sponsor Robert F. Witte Project NExT Fellows. The MAA will acknowledge Witte's long-time support by designating one or more Robert F. Witte Project NExT Fellows each year. Plans to establish an endowment for this purpose are underway. Contributions should be made to the MAA, with a note indicating that the donation is to support a Witte Fellow, at 1529 Eighteenth St NW, Washington D.C. 20036.



Robert F. Witte

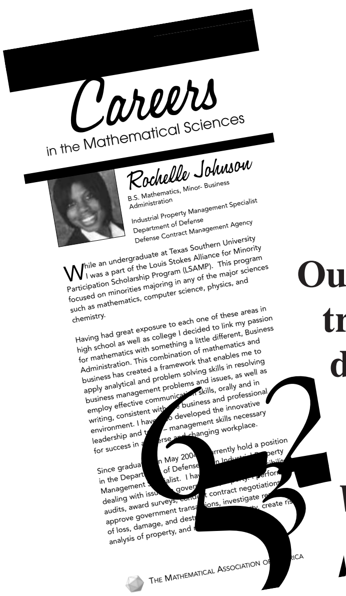
He is survived by his wife of 45 years, Pat, their three children and four grandchildren: Beth, Frank and Lauren Apollo of Bellaire, Texas; Rob, Diane, Kyle and Ty Witte of Irving, Texas; and Alison, Gary, and Karoline Beazley of Grand Prairie, Texas. He is also survived by his brother David Witte of Denver, Colorado, and an uncle, Ambrose Hoeger of Dubuque, Iowa.

In Memoriam

Serge Lang, well known number theorist and author of many important mathematics books, passed away on September 12 at the age of 78. Lang received his PhD under Emil Artin, then taught at Columbia and Yale. He received the AMS's Cole Prize in Algebra and also their Leroy P. Steele Prize for mathematical exposition. Lang wrote about all sorts of mathematics, from calculus to the frontiers of research in number theory, often being the first one out of the gate with a text on a new field, a service for which many graduate students have felt grateful to him.

James J. Kaput, professor of mathematics at the University of Massachsetts at Dartmouth, died at age 63 after a jogging accident on July 31, 2005. Kaput was well known for his work on mathematics education. According to the obitiuary in the *Boston Globe*, Kaput "was convinced that things like arcade games and hand-held devices were the keys to breaking down mathematical concepts so anyone could understand them." He taught at UMass Dartmouth for 25 years, received many NSF grants, and helped found SimCalc Technologies. Kaput was a member of the MAA for 28 years.

George and Esther Szekeres both died on August 28, 2005. George was 94, and Esther was 95. They were part of the brilliant group of Hungarian mathematicians of the 1930s which included Paul Turán and Paul Erdös. In the 1940s they moved to Australia and helped invigorate the Australian mathematics research community. George and Esther made significant contributions to number theory and combinatorics, and George also wrote on group theory and relativity.



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MAA Announces Search for Director of Publications

The Mathematical Association of America (MAA) is seeking a highly qualified person for the position of Director of Publications. A candidate should have a significant record of work in publications in the mathematical sciences; a Ph.D. degree in a mathematical science or mathematics education is preferred. The position requires successful experiences in all or most of the following areas: book publishing; journal production; administration including financial management; editorial/reviewing experience; mathematical writing not limited to research publications; and, electronic publications. Interest and experience with the use of the internet in publications, grants, personnel management, and marketing experience are desirable. A successful candidate should have a vision for the future of MAA publications. Appointments may be made for two or three years, with the option of renewal for multiple years.

The Director will oversee a staff of six located in the headquarters office and numerous editors. S/he oversees publication of three journals, three magazines, nine book series, and a variety of columns and articles. Electronic publications include all of these types of materials as well as the MAA Mathematical Sciences Digital Library (MathDL). The Director's duties include personnel management, financial administration, acquisitions, production, inventory control, grant proposal writing and project management, and marketing. The Director reports to the Executive Director. S/he is a key member of the MAA's staff leadership team, and will work closely with the Executive Director and other staff members, national officers, section officers, committee chairs, and others in strategic planning and program development.

The MAA, with nearly 30,000 members, is the largest association in the world devoted to college level mathematics. Membership includes college and university faculty and students, high school teachers, individuals from business, industry, and government, and others who enjoy mathematics. The Director of Publications is responsible for ensuring that publications encompass the interests of all major constituencies of the MAA, embrace all areas of mathematics, and are easily available to all our members and the larger community who are interested in mathematics, especially expository mathematics and materials for faculty and students.

The deadline for submission of applications is January 21, 2006. Interviews will be held during the months of January and February. It is expected that the new Director will begin work by July 2006, earlier if possible. The position is located at the national headquarters of the MAA in Washington, DC. Salary will be based upon the candidate's credentials or current salary for a reassignment position. The MAA offers a generous benefits package.

Candidates should send a resume and letter of interest to:

Ms. Julie Kraman
Mathematical Association of America
1529 18th Street, NW
Washington, DC 20036.

Applications may be submitted electronically to jkraman@maa.org. References will be requested after review of applications. Applications from individuals from underrepresented groups are encouraged. Additional information about the MAA and its publication programs may be found on MAA's website: http://www.maa.org . AA/EOE.

Call for AMC Volunteers

Interested in the American Mathematics Competitions (AMC)? Would you like to try your hand at anthropological fieldwork? Do you see yourself more as Lara Croft or Indiana Jones?

The AMC strategic planning working group of the MAA seeks volunteers to help with a study of high school teachers' attitudes about the American Mathematics Competitions (AMC). Instead of conducting a dry survey, we have hired an expert ethnographer/anthropologist to help us gather qualitative information about AMC participation.

Here is what you would be expected to do:

1. Attend a training session at the Joint Meetings in San Antonio. This is mscheduled for Thursday, January 12, 2006 from 5 pm to 7 pm.

2. Interview about five high school teachers by telephone (or in person if convenient).

3. Record your findings, using a convenient web interface to transcribe your field notes.

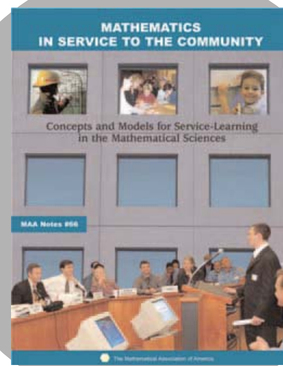
If you would like to help, please contact Frank Farris at ffarris@scu.edu. Unfortunately, we cannot offer travel support, but we believe that this interesting project will be well worth your time.

NEW NOTES FROM THE

MATHEMATICAL ASSOCIATION OF AMERICA

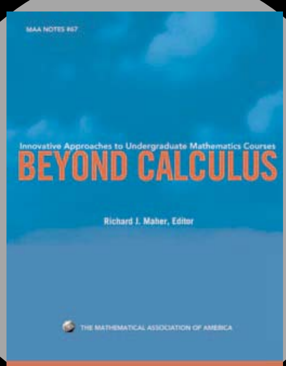
Mathematics in Service to the Community:
Concepts and models for service-learning in the mathematical sciences
Charles Hadlock, Editor

This book looks at the wide variety of ways in which math, statistics, and math education teachers have incorporated service-learning into their courses. These projects are not just stand-alone community service initiatives, but rather they specifically target the improvement of mathematics skills and insights of the college students in the courses with which they are associated. In some cases, the projects are the major focus of the courses. In others, they may range from an essential component to one of several options. The book also speculates about heretofore untapped possibilities for service-learning, even including courses in pure mathematics. College faculty often may not fully appreciate the wide range of support mechanisms for such ventures even within their own institutions, so the book includes a lengthy chapter on the details of converting a rough idea to a solid action plan, sometimes even picking up financial support and other often unexpected benefits along the way. Creative teachers rarely implement a project in exactly the same way as a colleague might have, so the emphasis here is to display a wide range of successful projects in order to encourage readers to develop some of their own.



MAA Notes • NTE-66 • 277 pp., Paperbound, 2005 • ISBN: 0-88385-176-8
List: $45.50 • MAA Member: $36.50

Innovative Approaches to Undergraduate Mathematics Courses Beyond Calculus
Richard J. Maher, Editor



This book describes innovative approaches that have been used successfully by a variety of instructors in the undergraduate mathematics courses that follow calculus. These approaches are designed to make upper division mathematics courses more interesting, more attractive, and more beneficial to our students. The authors of the articles in this volume show how this can be done while still teaching **mathematics** courses. These approaches range from various classroom techniques to novel presentations of material to discussing topics not normally encountered in the typical mathematics curriculum.

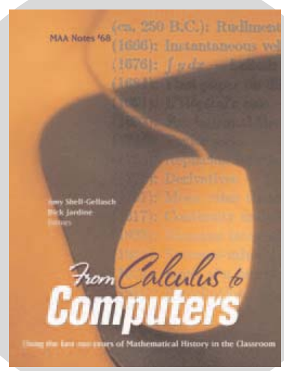
One overriding goal of all of these articles is to encourage students to stretch their mathematical boundaries. This stretching can be done in a variety of ways but there is one common theme; students expand their horizons not merely by sitting and listening to lectures but by **doing** mathematics.

MAA Notes • NTE-67 • 200 pp., Paperbound, 2005 • ISBN: 0-88385-177-6
List: $48.95 • MAA Member: $39.50

From Calculus to Computers
Using the Last 200 Years of Mathematics History in the Classroom
Amy Shell-Gellasch and Dick Jardine, Editors

Using the history of mathematics enhances the teaching and learning of mathematics. To date, much of the literature prepared on the topic of integrating mathematics history in undergraduate teaching contains, predominantly, ideas from the 18th century and earlier. This volume focuses on 19th and 20th century mathematics, building on the earlier efforts but emphasizing recent history in the teaching of mathematics, computer science, and related disciplines.

From Calculus to Computers is a resource for undergraduate teachers that provide ideas and materials for immediate adoption in the classroom and proven examples to motivate innovation by the reader. Contributions to this volume are from historians of mathematics and college mathematics instructors with years of experience and expertise in these subjects.



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Proof: Three Reviews

Proof, a movie based on David Auburn's Pulitzer Prize winning play, was released in September. Featuring Gwyneth Paltrow, Anthony Hopkins, and Jake Gyllenhaal in the main roles, the movie had a mixed reception by the critics. Given the important role of mathematics in the story, we decided to ask three people to have a look and tell us what they think. Harry Waldman is Head Writer for FOCUS. He works at MAA headquarters in the Publications Department, but in his spare time Harry has a strong interest in the cinema and has written several books about films. Melanie Wood is a graduate student at Princeton and a winner of the Morgan Prize for undergraduate research. Jackie Giles is a member of the FOCUS editorial board who teaches at Central College, part of the Houston Community College System.

Photo provided by Miramax Films; used with permission

Harry Waldman

At a key point in the new film *Proof*, the cinematic adaptation of David Auburn's award-winning play, Robert Llewelyn (Anthony Hopkins), in his early 60s, a former distinguished University of Chicago mathematics professor, says, "All cylinders are firing… the machinery is working." The "machinery" he's referring to, as his daughter Catherine (Gwyneth Paltrow) knows, is his mind. A world-renowned figure in mathematics, he's been absent form the field for years, but now he's evidently inspired and hard at work on a proof. Catherine, a fine math student, has cared for him as dementia — his long night of the living dead — has taken hold. She hopes beyond all reason that her revered father, who had made his name in Britain at the age of 22, is back. That would set her free.

The film, which also features the excellent British character actor Roshan Seth as Professor Bhandari, was co-scripted by Rebecca Miller — Arthur's daughter. Completed in late 2004 and one of the main entries at the recent Venice and Toronto film festivals, it tries to bring the arena of mathematics and its inhabitants to life. Set at the University of Chicago, it talks a good game, but doesn't show enough of mathematicians in action.

> *Proof* isn't just a movie about mathematics; it's a mathematical movie. The scenes may as well have been laid out by diagram: Let's put a touching father-daughter moment here, a startling revelation there, and use interstitial flashbacks to cube the total emotional-resonance quotient.
>
> Stephanie Zacharek
> *Salon*

But the film is not really about mathematics anyway. That's just a backdrop, window dressing, so to speak. The filmmakers have chosen mathematics as the metaphor through which to make their points, including a few about the field itself. There's the impression that mathematics is dominated by a few geniuses. That real mathematicians must show their talent early before they flame out. And that mathematics is too incomprehensible to show on the screen. Thus all we get is a bit of clichéd "mathematics."

We do, however, see a lot of mathematical books and journals — some of them from the Mathematical Association of America! Who are the people involved with this stuff? They are young wizards, we're informed, striving for greatness. The world of rarefied mathematics, apparently, requires genius and its substantiation. If you can't maintain the lofty mathematics — exemplified by a proof so original that it causes your colleagues' heads to spin — you might as well head for the hills. The young mathematicians have only a bit of time: the clock is ticking. There are those in the mathematics community who believe this but others, like Catherine, disagree. So implies the new film from director John Madden.

Then again, Robert may be the exception to this rule. Although he's suffering from dementia, he just might have come up with a major mathematical proof late in life that will set the math world ablaze and restore him to his former glory. Or is this mysterious "proof," which Catherine has uncovered, not really his? Has she perhaps inherited her father's genius? Does the future hold promise or peril for her? Is she her father's daughter in more ways than one?

Self-centered young graduate mathematics student Hal (Jake Gyllenhaal) represents the young mathematicians. He teaches, he coaches young hockey players, he plays drums in a band. He's no geek. When we first meet Hal, he's wearing glasses. That's the last time he can see clearly, so to speak. After that, sans spectacles, he grows stubble and is in it for the *glory*. Getting close to Catherine, he offers her a way out of her emotional bind. He's fond of saying, "There's nothing wrong with you."

> Because it takes itself so seriously, some viewers might come away convinced that *Proof* is a substantial work of art. You couldn't prove it by me.
>
> Colin Covert
> *The Star Tribune* (Minneapolis)

So the film comes down to proofs of love and trust in other ways. Catherine's proof is of her commitment and love for her father, the sacrifices she makes for him as his life ends — and of her career choices. It's also about proof of Hal's trust and love for her, and hers for him. However, her father's final years have been a nightmare for her. She had to make sacrifices socially and educationally. She couldn't pursue her work because her father couldn't manage without her.

We do see that Catherine is depressed and in mourning even while her father is alive but in decline. Her sister Claire (Hope Davis), is a rather clear-headed New Yorker, although she is portrayed as materialistic and hyperorganized. Having perhaps inherited these characteristics of her father, she has already given up on him. There's never a scene between her and Robert. Claire arrives in Chicago to try to get her sister, who appears to her to be in need of psychiatric help, out of there. Catherine, a masochist of a sort, will have none of Claire or her ideas.

What's perhaps most notable in the 100-minute film for MAA members is that the MAA contributed several hundred journals and books to the producers of this film so that they could recreate the ambience of a real mathematician's office. Look, therefore, for some of the real mathematics in the film: the *American Mathematical Monthly*, the *College Mathematics Journal*, and *Mathematics Magazine*.

Melanie Wood

You should see the movie *Proof* — but not just because you are a mathematician. Feel free to take along non-mathematician friends or recommend it to your relatives. *Proof* is an emotionally compelling drama, which manages to present a fresh story without resorting to the laughingly preposterous premises that are the recent formula for an original plot. Gywneth Paltrow drives the show with her convincing portrayal of Catherine, the daughter of mathematician Robert (Anthony Hopkins) who has gone crazy in his later years and requires the constant attention of his daughter. At the start of the movie, Robert has just died, and his other daughter Claire (Hope Davis) flies in for the funeral and to take care of Catherine. Claire's overbearing manner is not the only annoyance Catherine also faces. Hal (Jake Gyllenhaal), a former student of Robert's, wants to go through over a hundred notebooks left by Robert to see if there is any new mathematics in them. Catherine is grieving and struggling to cope with her father's death and what this means for her own life.

> Against considerable odds and despite a shaky start, *Proof* proves itself in every area. Thanks largely to Paltrow's beautifully unadorned performance, an exceptional portrait of psychological fragility that is honest, direct and devastating, this is a film that really has to be seen.
>
> Kenneth Turan
> *The Los Angeles Times*

At first, the movie deals with the issues of grieving, insanity, caring for ill parents, and though it is engaging in these aspects, it might leave you wondering when they are going to get to the math (and might leave everyone else in the audience relieved!). A few early mathematical jokes will allow you to identify your compatriots in the audience, but mostly the mathematical issues come late in the movie. A proof is discovered in a notebook in Robert's desk and raises a question of the authorship. Was the proof done by Robert when everyone thought he was insane and incapable of work? Or is it possible that his daughter Catherine, a talented mathematics student, but not even finished with her education, could be the author? (Warning: the rest of review gives the answer.)

> The drama of the sisters and Hal and the past-and-present father drags a bit because some of the time it seems to be not much more than elevated bickering. All in all, this is the sort of work that gets credit for more gravity than it genuinely possesses, merely because of its subject.
>
> Stanley Kauffmann
> *The New Republic*

Before it was a movie, *Proof* was a Pulitzer Prize play, which ran on Broadway and won Tony Awards for Best Play, Best Actress, and Best Director. Of course, the movie medium changes a lot in the presentation, but there were two big changes in substance from the play that were both disappointing. In the play, it is made clear early on that Robert did not do lucid mathematics in his relapse from insanity, and in particular, that the proof must be Catherine's. Knowing that the work is Catherine's, we in the audience sympathize with this woman not only because her sister and new boyfriend don't seem to trust her, but also because her mathematical work is not recognized.

The movie takes a different approach, presumably to maximize suspense or set up a big plot twist. We are led to believe that Robert was able to start working during his relapse, and moreover that he had a program for a proof of an important result. Catherine also starts her own mathematical work, and it is possible they are working together. In a breakdown, Catherine even seems to claim that she has stolen the proof from her dad.

The movie does in the end make it almost clear that the proof is Catherine's, except that one very mysterious scene is left unexplained. While watching a movie, Catherine tells her father of her progress on some result, and he makes a suggestion — apparently a good one, judging by her reaction. This scene not only contradicts the impression that Robert was not able to do mathematics after his mental problems began, but also raises questions. Even if Catherine worked out the details, if her father gave her suggestions, was it really her proof? Could he have given her really significant suggestions? Could he have outlined the whole thing? This leads the audience to disbelieve Catherine, and thus makes it harder for them to feel sympathy for her plight.

Photo provided by Miramax Films; used with permission

This change also means that the movie loses the chance to unequivocally portray a young woman as an excellent mathematician who thinks in new and creative ways.

The second major change from the play is that Catherine is portrayed as actually having mental problems (the play makes that questionable at best). She appears to be more disturbed than just by normal grief. The movie uses flashing colors and scenes and lights going by quickly in one scene to give an impression of insanity. While it is exciting for mathematics that there have been two recent major motion pictures portraying mathematicians, it is unfortunate that they both feature mathematicians with significant psychological problems.

One of the repeated themes of *Proof* is that mathematicians do their best work by the time they are 26, and by 27 it is all downhill. Many of my colleagues were a little depressed by the movie for this reason. The movie's end underscores this idea since the important proof was in fact done by Catherine (before she turned 27), and not by her older father. Another interesting "observation" made is mathematicians' inclination for serious partying and use of speed. I am not sure what that will do for recruitment into our field.

Jacqueline Brannon Giles

As I viewed the movie *Proof* I tried to strip myself of the tendency to compare and contrast it with other movies about mathematicians. I wanted to study the movie as a single unit of entertainment. The dedication and compassion of a young female mathematician (Catherine) who cared enough about an ailing, yet renowned older mathematician, was touching and heart warming. It was the intergenerational connecting and caring that impressed me.

> The point lies in a darker place — at the intersection of insanity and genius, and the inheritance of both. It asks if pathology can be separated from gift. It wonders if a wunderkind will fade past his 20s, or if the child of a madman is doomed to crack. And it talks about math like music.
>
> Amy Biancolli
> *The Houston Chronicle*

Catherine's birthday, possibly marking the beginning of her decline in capability, was also the day of her father's burial. This highlighted both transition and continuity, for in the daughter's struggle to aid her father she was inspired to do her best work. The death of the father spawned the birth of the daughter.

Catherine's intimate interaction and constant contact with her father, who was also her mentor and her teacher, spurred on the genius in her. Nevertheless, she deposited her work in a drawer only to be shared after her affection for the young man (Hal) was acted on. Once she felt free to emote and share with Hal, she was willing to share the treasured mathematical thoughts in her notebook. It suggested to me that her development as a female preceded her full development as a mathematician.

A schism occurred because of distrust among the characters, yet there was a satisfying resolution at the end. The daughter, together with her father's former student, went on to affirm and improve the mathematical work inspired by her father, who sincerely desired that his daughter would "do" mathematics. While the movie leaves this somewhat undecided, I believe that the father's hope was indeed actualized in the decision of the daughter to continue the legacy of "writing and doing mathematics." This could easily be a visionary statement for the senior mathematicians in our professional community; Out of the decline and death of our great mathematicians should come the birth and rise of the next generation of mathematicians.

convergence:

Where Mathematics, History and Teaching Interact





Convergence: Where Mathematics, History and Teaching Interact, is the MAA's new online magazine in the history of mathematics and its use in teaching. *Convergence* is a resource and forum for mathematics teachers of high school classes and lower-division college classes who want to use the history of mathematics to engage and motivate their students and help them better understand the mathematical ideas. The editors, Victor J. Katz, from the University of the District of Columbia, and Frank Swetz, from Penn State University, Harrisburg, welcome all mathematics teachers to visit the *Convergence* website (http://convergence.mathdl.org) and see what the magazine has to offer.

The magazine includes:

- Expository articles dealing with the history of various topics in the mathematics curriculum, each accompanied by an online discussion group.
- Translations of original sources, with commentary showing the context of the works.
- Reviews of current and past books, articles, teaching aids, and websites on the history of mathematics.
- Classroom suggestions.
- Historical problems.
- *What Happened Today in History?*
- Quotation of the day.
- An up-to-date calendar of meetings dealing with the history of mathematics and its use in teaching.

The magazine is currently free to all, although registration is required. We encourage you to log on, to use the material in your classes, to participate in the discussion groups, and to contribute new articles based on your own experiences.

Convergence: http://convergence.mathdl.org

The Mathematical Association of America ®

Letters to the Editor

Found Math: Mathematics and Football

Tsk, tsk. Both Ms Bazemore and the WSJ flubbed this one. (FOCUS, August/September 2005, "Found Math" on page 43.)

Bazemore, with any background in math, should merely have stated that the explanation of how this could have happened is left as an exercise for the reader.

The WSJ editors, having no significant sports staff, could have pulled in any kid off the street who would have pointed out that on fourth down the team threw a "Hail Mary" pass which was intercepted 30 yards downfield, run back 23 yards where the ball was fumbled and recovered by the passing team. It could just as easily have been a fumbled punt return.

I'm sure you'll get hundreds of similar letters, mostly from mathematicians.

Phil Stein

As you might expect the ***Best of the Web*** *column also got many such responses, all of which pointed out interesting scenarios. You can see these responses at the Opinion Journal site: the original item is at* http://www.opinionjournal.com/best/?id=110006727 *(last item), and the comments on the replies at* http://www.opinionjournal.com/best/?id=110006731 *(look for "Figuring Football." But of course the point was not that such scenarios did not exist, but rather that Ms. Bazemore's answer reinforces the notion that mathematicians are all too casual about the connection between mathematical problems and the real world.*

Sample Mound Master Question Raises Doubts

The third "Sample Mound Master Question" in the article "Math Youth Days at the Ballpark" in the August/September issue of FOCUS caught my attention:

"The Sky Sox play at the AAA level, one step below the major leagues. Over the years, 75% of Sky Sox players have gone on to the majors. If the Sky Sox currently have 24 men on their roster, how many of the current players would we expect to go on to the majors?"

We don't have enough information to solve this problem, but I expect the true answer is significantly less than 75% of 24, or 18.

For a concrete model, let's assume that a player who gets promoted to the majors plays for the Sky Sox for 2 years first, while players who don't get promoted stick around for 6 years before giving up. Suppose further that each year 2 players give up and retire, while 6 players are promoted to the majors. These 8 players are replaced by 8 new players, of whom 6 will eventually get promoted in 2 years and 2 will retire after 6 years. Clearly 75% of all players go on to the majors. But each season we have 6 first year players who will eventually be promoted, 6 second year players who will be promoted, and 2 players each in years 1, 2, 3, 4, 5, and 6 who will never be promoted. Thus in any given season we have 12 players who will eventually be promoted to the majors and 12 who will not.

My model is clearly overly simple, and my numbers might not be realistic, but it clearly illustrates the fact that the percentage of all players who eventually go on to the majors is not at all the same thing as the percentage of players at any one time who will eventually get promoted to the majors.

Paul K. Stockmeyer
College of William and Mary

Gene Abrams replies:

It is indeed the case that, as indicated quite correctly in the comment by means of a particular model, that "the percentage of all players who eventually go on to the majors" is not at all the same thing as "the percentage of players at any one time who will eventually get promoted to the majors." I thank Prof. Stockmeyer for pointing this out.

Here would be a better (at least a mathematically precise) way to phrase a question of the type I am trying to convey:

"Historically, a large percentage of players who play for the Sky Sox eventually go on to play in the major leagues. The Sky Sox currently have 24 players on their roster. Suppose that 75% of the players on the current roster eventually go on to play in the majors. How many future major leaguers are there on the current roster?"

Or indeed the mathematical format of the question could be changed to:

"Historically, a large percentage of players who play for the Sky Sox eventually go on to play in the major leagues. The Sky Sox currently have 24 players on their roster. Suppose that 18 of the players on the current roster eventually go on to play in the majors. What percentage of the current roster consists of future major leaguers?"

I will definitely change the wording of this type of question in the future.

What is now somewhat interesting to me is the following. The Sky Sox media people are fond of using the following statistic in their advertising: "73% of Sky Sox players go on to play in the majors." In the context of the current discussion, I guess there could be more than one interpretation of that phrase!

Intermountain Section Award Winner

In the August/September 2005 FOCUS, the winner of the Intermoutain Section Award is correctly reported to be Afshin Ghoreishi. However, that report fails to say that Professor Ghoreishi teaches at Weber State University. For every other winner the institutional affiliation is given.

Lee Badger
Weber State University
Chair of the Intermountain Section

Chicken Nuggets Puzzler

Thought you might like to know that our math club worked at its first meeting on the puzzler in the August/September issue of FOCUS (page 45). It was perfect for that group and we had fun figuring it out.

I also wonder whether any readers came up with the same outside-the-box idea I did. See, you go into McDs and order nine 9-piece boxes, and also ask for four empty 20-piece cartons. Take the food to your table, and repack 80 of the 81 pieces into the 20 piece cartons, then go back to the counter and ask for a refund on four 20 piece containers. That leaves you with 1 piece, and so allows you to fill any order. If you can talk McDs into buying back chicken pieces, you convert the problem into one permitting any integer coefficients, and so you can fill any order of size a multiple of the GCD of the box sizes.

Dan Kalman
American University

More on Nuggets

I was vastly amused by seeing that problem in the most recent issue of FOCUS. I believe I am the source, although I guess someone else could have come up with it independently.

It happened 20 years ago, when my son had a summer job at the McGill computing centre and we walked together downtown. My office was in the same building as he worked. About 3/4 of a mile from our house, we pass a McDonald's and he mentioned as we passed by that quite frequently he and his friends would go in and buy a load of McNuggets. He then told me that they come in boxes of 6 and 9 and buckets of 20. One of us (I don't recall which), then came up with the question. We answered it and continued on our way. Then after he graduated and was elected to the engineering honors society, we started receiving their official magazine, *The Bent*, which features a puzzle page every issue. Although my son was living elsewhere, the magazine came to our house and I noticed it.

Eventually I thought to send in this puzzle and it got duly printed. Since my son graduated in 1988, this was probably in 1990 or 91. I forgot about it then until my other son got a master's from MIT and started receiving their alumni magazine *Technology Today* and saw the exact same problem in their problem section (which seems to appear in alternate issues). It was probably about three years ago that it appeared. It is not a great stretch to suppose that some MIT alumnus had been a member of the honor society and seen it *The Bent*, but forgotten its provenance by then. Then I saw in the sci.math newsgroup one day and made some attempt to determine if *The Bent* appearance was the earliest, but no one who responded had ever even seen that appearance. So, while it would take some research to find out if it all goes back to my contribution, I can choose to believe it.

Michael Barr
McGill University

2006 MAA Membership Renewals

Check the mail for your 2006 MAA Membership renewal notice.

We appreciate your continued support of the MAA.

Correction

In the October issue of FOCUS on page 26 we listed the NAM Reception and Banquet as taking place on Friday, January 13, 2006 from 6:00 p.m. to 9:30 p.m. The NAM Reception and Banquet will be held on Saturday January 14, 2006 from 6:00 p.m. to 9:30 p.m. On page 27 we listed the AMS Reception and Banquet as being held on Saturday, January 14, 2006 from 6:30 p.m. to 10:30 p.m. The AMS Reception and Banquet will actually be held on Sunday, January 15, 2006 from 6:30 p.m. to 10:30 p.m. We are sorry for the errors.

MAA Prizes and Awards Announced at MathFest 2005

The awarding of prizes for expository writing has long been one of the high points of MathFest. The Alder Award, for younger teachers, has added a prize for distinguished teaching to the annual MathFest awards ceremony. These pages list the awards offered at MathFest; more details, including full citations and responses, can be found online at http://www.maa.org/news/080105mfwa.html.

MAA President Carl Cowen presides over the awards ceremony at MathFest.

George Pólya Award

For articles published in the *College Mathematics Journal*
There were two Pólya Awards this year:

Stephen M. Walk
for "Mind Your ∀s and ∃s"
College Mathematics Journal, v. 35
November 2004, pp. 362-369.

Brian Hopkins

Brian Hopkins and Robin J. Wilson
for "The Truth About Königsberg"
College Mathematics Journal, v. 35
May 2004, pp. 198-207.

Trevor Evans Award

For articles published in *Math Horizons.*

Robert L. Devaney
for "Chaos Rules!"
Math Horizons
November 2004, pp. 11-14.

Merten M. Hasse Prize

For a noteworthy expository paper appearing in an MAA publication, at least one of whose authors is a younger mathematician

Maureen Carroll and Stephen Dougherty
for "Tic-Tac-Toe on a Finite Plane"
Mathematics Magazine, v. 77, no.4
October 2004, pp. 260-274.

Carl B. Allendoerfer Award

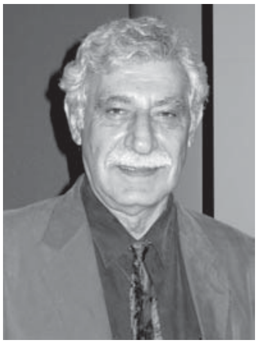
For articles published in *Mathematics Magazine*

Robert B. Eggleton and William P. Galvin (posthumously)
for "Upper Bounds on the Sum of Principal Divisors of an Integer"
Mathematics Magazine, v. 77
June 2004, pp. 190-200

Professor Eggleton was unable to attend.

Lester R. Ford Award

For articles published in *The American Mathematical Monthly*
There were five Ford Awards this year:



Mamikon Mnatsakanian

Tom Apostol and Mamikon Mnatsakanian
for a series of three articles:

"Isoperimetric and Isoparametric Problems," *The American Mathematical Monthly,* v. 111, no.2, February 2004, pp. 118-136.

"A Fresh Look at the Method of Archimedes," *The American Mathematical Monthly,* v. 111, no.6 June/July 2004, pp. 496-508.

"Figures Circumscribing Circles," *The American Mathematical Monthly* v. 111, no.10, December 2004, pp. 853-863.

Henry Cohn
for "Projective Geometry over 1and the Gaussian Binomial Coefficients" *The American Mathematical Monthly*, v. 111, no.6, June/July 2004, pp. 487-495.

Alan Edelman

Alan Edelman and Gilbert Strang
for "Pascal Matrices"
The American Mathematical Monthly
v. 111, no.3, March 2004, pp. 361-385.

Steven Finch and John Wetzel
for "Lost in a Forest"
The American Mathematical Monthly, v. 111, no.8
October 2004, pp. 645-654.

Professors Finch and Wetzel were unable to attend.

Judith Grabiner
for "Newton, Maclaurin, and the Authority of Mathematics"
The American Mathematical Monthly, v. 111, no.10
December 2004, pp. 841-852.

Professor Grabiner was unable to attend.

Chauvenet Prize for Expository Writing

The Chauvenet Prize is given for an outstanding expository article on a mathematical topic by a member of the Association.

John Stillwell
for "The Story of the 120-Cell"
Notices of the AMS, January 2001, pp. 17-24.

Henry L. Alder Award for Distinguished Teaching by a Beginning College or University Mathematics Faculty Member

The Alder Awards honor beginning college or university faculty whose teaching has been extraordinarily successful and whose work is known to have had influence beyond their own classrooms. This years winners are:

Matthew DeLong
Taylor University

Sarah Greenwald
Appalachian State University

Laura Taalman
James Madison University

MAA Business at MathFest 2005

By Martha Siegel, Secretary of the Association

MathFest in Albuquerque marked the beginning of a new era for the MAA. For the first time, our in-house meetings staff managed the entire summer meeting. Associate Secretary Jim Tattersall; Director of Membership, Marketing and Meetings Jim Gandorf; Director of Programs and Services Michael Pearson, and their staff did a great job. Knoxville MathFest in 2006 will be even better!

The MAA and all of its members should congratulate the newly elected officers of the MAA. They will take office after the January 2006 Joint Mathematics Meetings: Joe Gallian, President-Elect, Carl Pomerance, First Vice-President, and Deanna Haunsperger, Second Vice-President.

The Association is currently engaged in a strategic planning process. First Vice-President Barbara Faires heads the planning effort. We are in the midst of examining three important areas: Revenue, the American Mathematics Competitions, and Professional Development. Working Groups, appointed by the President and chaired by Barbara Faires, Frank Farris, and Nancy Hagelgans, respectively, are meeting with our staff with a timetable that requires final reports next November. At its meeting on August 3, the Board of Governors voted that the next three areas of study should be Membership, Students, and Governance. Working Groups will be formed shortly.

Deanna Haunsperger newly elected Second Vice-President.

In other Board action, the Board approved a revision of the short version of the mission statement to be posted online and in other MAA documents. The old statement said: **The Mathematical Association of America is the largest professional society that focuses on undergraduate mathematics education.** The new statement says: **The Mathematical Association of America is the largest professional society that focuses on mathematics accessible at the undergraduate level.**

Joe Gallian, MAA President-Elect

The Board welcomed new Section Governors: John Bukowski of the Allegheny Mountain Section, Richard Gillman of the Indiana Section, Dan Curtin of the Kentucky Section, John A. Winn, Jr. of the Metro New York Section, Christopher Masters of the Nebraska–SE South Dakota Section, Kathleen Hamm of the Northern California Section, Frederick Worth of the Oklahoma–Arkansas Section, Jane Arledge of the Rocky Mountain Section, John Koker of the Wisconsin Section. It also thanked the outgoing governors: Donald M. Platte, Roger B. Nelson, Rodger Hammons, Raymond N. Greenwell, John Fuelberth, Leonard F. Klosinski, Lisa Mantini, Hortensia Soto-Johnson, and Richard Poss, respectively.

Governors-at-Large were elected by the Board to begin a three-year term beginning after the January 2006 Joint Mathematics Meetings: Jeremy Kilpatrick of the University of Georgia was elected Governor-at-Large Representing Teacher Education, replacing Joan Ferrini-Mundy; Peter Stanek, Lockheed (ret.), was elected Governor-at-Large Representing Mathematicians Outside Academia, replacing Peter DeLong.

Future meetings of the Association, approved by the Board of Governors can be found on the MAA web site. The Board approved two additional ones pending successful contract negotiations: the **2012 Joint Mathematics Meetings**, to be held in Boston, Massachusetts, on January 4–7 (Wednesday-Saturday), and the **2013 Joint Mathematics Meetings**, to be held in San Diego, California, January 9–12 (Wednesday-Saturday).

Daniel Maki was reelected to a four-year term on the Audit and Budget Committees. Lowell Beineke, Editor of *The College Mathematics Journal*, was elected to serve a two-year term on the Executive Committee representing publications. Nancy Hagelgans was reelected to a three-year term as Chair of the Committee on Sections. As provided in the By-laws, she will serve another three-year term on the Board of Governors and on the Executive Committee of the Association.

Allen Schwenk of Western Michigan University was elected by the Board to serve as Editor-Elect of *Mathematics Magazine* from January 1, 2005 to December 31, 2005. He will assume the responsibilities of Editor on January 1, 2006. The Board approved the incoming editorial board of the *Magazine*.

The Board elected Daniel Velleman of Amherst College as Editor-Elect of *The American Mathematical Monthly*, to succeed its current Editor, Bruce Palka. The Editor-Elect begins his term on January 1, 2006 and will become editor in 2007, for a term of five years.

The Board approved Meritorious Service Awards for six sections and selected three outstanding teachers as winners of the 2006 Deborah and Franklin Tepper Haimo Awards. The Board also approved the winner of the Gung-Hu Award for Distinguished Service to Mathematics. These honors will be presented at the Joint Prize Session in January 2006. See page 3 for more on the Haimo Award winners.

Francis Edward Su of Harvey Mudd College was elected James R. C. Leitzel Lecturer for MathFest 2006, and Tim Gowers of Cambridge University was elected Earle Raymond Hedrick Lecturer for MathFest 2006. Bernd Sturmfels of University of California Berkeley was elected Pólya Lecturer for 2005–06 and 2006–07. President Cowen thanked the outgoing Pólya Lecturer, Martin Isaacs of the University of Wisconsin Madison.

The Board approved the regulations for the MAA's **David P. Robbins Prize in Algebra, Combinatorics, and Discrete Mathematics**. The Board also revised eligibility guidelines for the Henry L. Alder and the Deborah and Franklin Tepper Haimo Awards. As soon as final revisions have been made, the regulations will be posted on the MAA web site.

In addition, the Board approved changes in the section bylaws of the Allegheny, Iowa, and Kansas Sections, and approved a change in the MAA Bylaws Article VI, Section 2 and discussed a corresponding change in the "model" Section Bylaws. As required by the Bylaws themselves, the Bylaws change is presented in detail in this issue of FOCUS (on page 12) and will be voted on at the Business Meeting of the MAA to be held during the January Joint Meetings.

JimTattersall, MAA Associate Secretary

MAA grants and program activities continue to increase. Ideas come from our active member-volunteers who serve on committees and from the very able staff. We have more than 10 projects currently active, including our PREP workshops and are being funded for many programs and activities including a large assessment project and undergraduate research centers and conferences.

Our bottom line this year is an operating surplus of almost $600,000. The completed 2004 audit was very positive, acknowledging the great improvement in Association finances and financial procedures in recent years. The total income from publications in 2005 seems to be on target, thanks to the efforts of our Publications staff and our fine group of member-Editors. We cannot rest on these laurels, though. External funding is likely to be more competitive, especially in the collegiate mathematics area, so we continue to try to increase revenue and control spending.

The Carriage House Conference Center, funded with a generous gift from Paul and Virginia Halmos, is progressing well. The renovation of the historic building behind 1529 Eighteenth Street is now in the hands of our architect and, pending permits, we are about to begin the construction. Active Programming Committees for the Center are planning for the future now.

One of the most ambitious projects of the MAA now in the implementation phase is the CUPM study of the undergraduate mathematics curriculum originally led by chair Harriet Pollatsek. David Bressoud, the new chair of CUPM has arranged many opportunities for MAA members to hear about the implementation of the recommendations, which have Board approval. Reference to the CUPM page will lead you to the Illustrative Resources that are being developed by Susanna Epp and her committee to accompany this effort.

The Third MAA Mathematical Study tour was a great success in its visit to Mexico this spring. Check MAA Online on September 1 for the announcement of the 2006 trip — June 6- 21 to China.

The array of programs, publications, services, and activity in the MAA is mind-boggling. We thank the staff and the many member-volunteers who make it all happen! Hope to see everyone in San Antonio in January.

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 (http://www.maa.org) or call (800) 331-1622, fax (301) 206-9789, email: maaservice@maa.org, or mail to the MAA, PO Box 90973, Washington, DC 20090.

MathFest 2005 in Pictures

Carl Cowen welcomes all at the Opening Banquet.

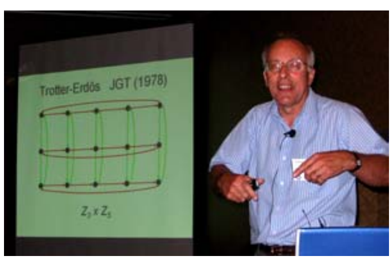
Packed escalator in the Convention Center, with rainbows provided by the suspended prisms.

Lowell Beineke buys some MAA gear for his granddaughter.

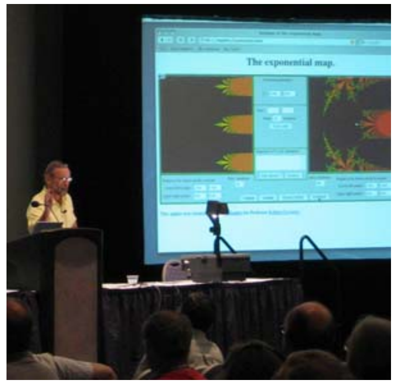
Statues near one of the entrances to the hotel.

Suspended prisms in the Convention Center.

Don Albers, Richard Guy, and Jack Graver before the Silver and Gold Banquet.



Joe Gallian lectures at the Opening Banquet.



Bob Devaney talked about iterating the exponential map.

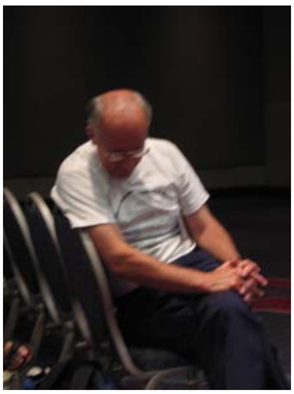
Main entrance of the Albuquerque Convention Center.

MAA staff at the Los Amigos Roundup: Jurgita Schwan, Jim Gandorf, Rich Hamilton, Lisa Kolbe, and Tina Straley.

MAA President Carl Cowen introduces the Hedrick Lectures.

President-elect Joe Gallian and Colm Mulcahy.

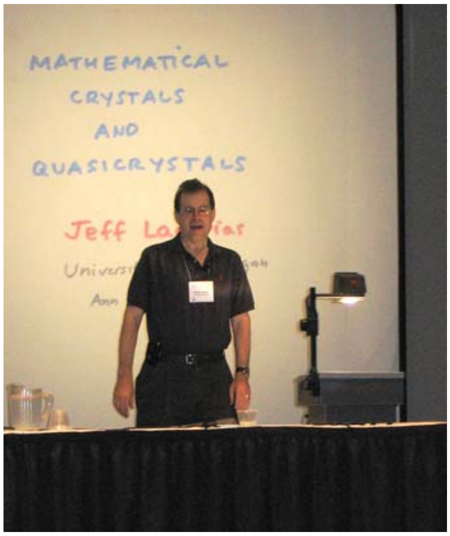
The activities table: fun for everyone.



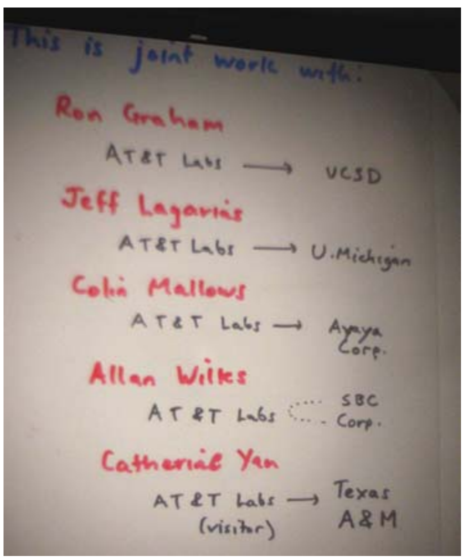
A pensive Joe Gallian at the MAA Business Meeting.

Harold Reiter and Richard Anderson at the President's Reception at the National Atomic Museum.

MAA Associate Secretaries, past and present: Jim Tattersall, Ken Ross, and Don Van Osdol.

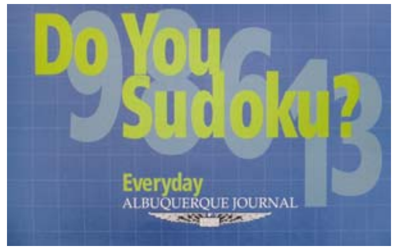


Hedrick Lecturer Jeff Lagarias does his thing.



Jeff Lagarias' co-authors and their fates after the dot-com bubble.

After hours: Bev Ruedi, Lisa Kolbe, and Elaine Pedreira of the MAA headquarters staff.



The Sudoku craze had arrived in Albuquerque.

Carol Baxter, managing editor of FOCUS, did her part at the registration desk.

Nathaniel Dean introduces Blackwell Lecturer Leona H. Clark.

Lisa Kolbe sells MAA gear.

Three generations of Beinekes: Lowell, Jennifer, and Anna Rose.

Ken and Ruth Ross preparing to lift off.

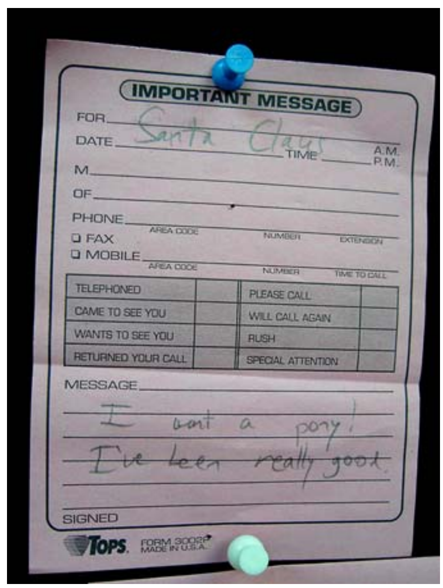
Twenty-five year members of the MAA at the Silver and Gold Banquet.

Gizem Karaali (UCSB) and Michael McJilton (College of the Desert).

Did she attend any of the talks?

Math and Science T-shirts on sale.

The Man in Charge: Jim Gandorf, MAA Director of Membership, Marketing, and Meetings.



A particularly important message.

Wood Mobius exhibited Möbius strips; see http://woodmobius.com.

Todd Shayler, Carl Erickson, and Nathaniel Watson, all participants in this year's SMALL program at Williams College.


El Editor


Fifty-year members of the MAA at the Silver and Gold Banquet.


Don Albers and Beverly Ruedi of the MAA Publications Department.


The eInstruction exhibit displayed innovative educational software.

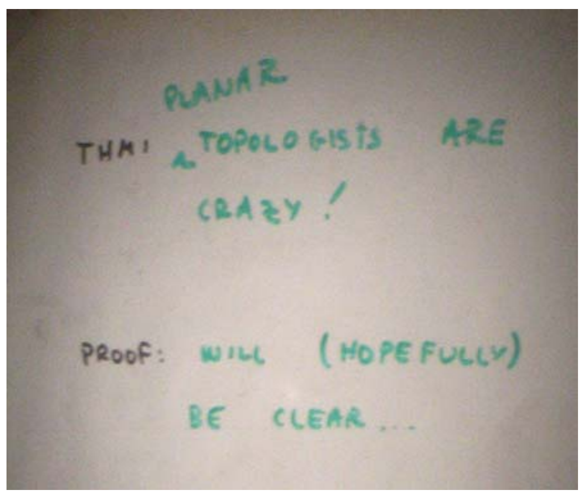

Water was essential for everyone.


Checking email could be done inside the exhibit area.


The mathematicians are thataway.


Madilyn Magno, daughter of MAA staffer Gretchen Magno, models MAA babywear.


At the Board of Governors meeting, some of the Powerful Ones: Second Vice-President Jean Bee Chan, Secretary Martha Siegel, President Carl Cowen, Executive Director Tina Straley, and Parliamentarian Wayne Roberts.



Bob Devaney explains about topologists.

Supporting Assessment in Undergraduate Mathematics

A Special Report

Driven by quests for more coherence in the curriculum and more accountability for learning produced, during the last quarter century assessment has become much more prominent in U.S. higher education. Most of the initial pressure for assessment came from sources external to the faculty — from accrediting agencies, governing boards, and university administrations. Thus early assessment work by disciplinary faculties was largely motivated by the need to respond to these external pressures. Nonetheless, the underlying goal of improving courses and academic programs so that student learning increased is of paramount importance. This has been the guiding principle of MAA's support of assessment in undergraduate mathematics over the past fifteen years.

MAA's support of assessment has consisted of three major components, roughly in five-year intervals during the fifteen years, 1990-2005. This special report concerns the third of those components, which was largely underwritten by a 2001 grant from National Science Foundation to support a project entitled Supporting Assessment in Undergraduate Mathematics (SAUM).

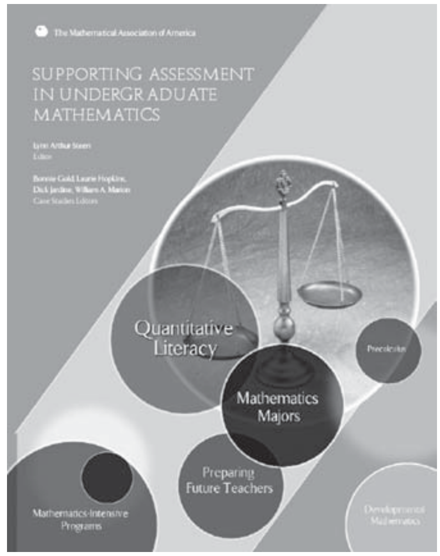
MAA's work in assessment began in 1990 with the appointment of the CUPM Subcommittee on Assessment. In 1995 the Subcommittee issued guidelines for departments to use in establishing a cycle of assessment aimed at program improvement (CUPM, 1995). The second component included use of these guidelines in mini-courses and other awareness activities, culminating in 1999 with publication of *Assessment Practices in Undergraduate Mathematics*, MAA Notes #49 (Gold, *et al.*,1999). This volume contains over seventy case studies of assessment in undergraduate mathematics and includes CUPM's 1995 assessment guidelines in an appendix. Prefaces to this volume offer additional context for MAA's support of assessment throughout the 1990s.

In the initial phase of the SAUM project, copies of *Assessment Practices in Undergraduate Mathematics* were sent to every college and university mathematics department in the United States. In subsequent years project personnel led forums on assessment at meetings of MAA's regional sections and arranged four series of multi-session workshops to support assessment efforts on individual campuses. These workshops brought together teams of faculty to develop their own assessment plans and to share both progress and impediments with colleagues from other institutions. Case studies emerging from these workshops, reviewed and edited by project staff, have now been published by the MAA both on-line and as a printed volume (Steen, et al., 2005). Other activities of the SAUM project included a mini-courses, poster sessions, invited and contributed paper sessions, an "assessment reception," and a website (http://www.maa.org/saum/) which MAA will maintain as a permanent Internet home for support of assessment in undergraduate mathematics.

This special section of FOCUS contains adaptations of three essays that introduce the SAUM case studies. Pull-quotes contain observations derived by project leaders from the case studies themselves.

SAUM Personnel

The SAUM project was directed by Bernard L. Madison, Professor of Mathematics at the University of Arkansas with the assistance of Bonnie Gold (Monmouth University), William E. Haver (Virginia Commonwealth University), Laurie Hopkins (Columbia College), Richard Jardine (Keene State College), Sandra Z. Keith (St. Cloud State University), William A. Marion, Jr. (Valparaiso University), and Lynn A. Steen (St. Olaf College). MAA Associate Executive Directors Thomas W. Rishel and Michael Pearson managed the project, while Peter Ewell, vice president of the National Center for Higher Education Management Systems (NCHEMS) served as project evaluator.



A complimentary copy of the new SAUM report is available to the first 1000 departments submitting requests through the project website http://www.maa.org/saum, *where you can also access the full text of the report.*

References

Committee on the Undergraduate Program in Mathematics. (1995) "Assessment of Student Learning for Improving the Undergraduate Major in Mathematics," FOCUS 15(3) (June, 1995) 24-28. Reprinted in *Assessment Practices in Undergraduate Mathematics*, Bonnie Gold, *et al.*, eds. Washington, DC: Mathematical Association of America, 1999, p. 279-284. http://www.maa.org/saum/maanotes49/279.html

Gold, Bonnie, Sandra Z. Keith, and William A. Marion (1999). *Assessment Practices in Undergraduate Mathematics*. MAA Notes No. 49. Washington, DC: Mathematical Assoc. of America. www.maa.org/saum/maanotes49/index.html

Steen, Lynn Arthur, et al. (2005) *Supporting Assessment in Undergraduate Mathematics: Case Studies from a National Project*. Washington, DC: Mathematical Association of America.

Tensions and Tethers
Assessing Learning in Undergraduate Mathematics

By Bernard L. Madison

In 2001, after a decade of encouraging and supporting comprehensive assessment of learning in undergraduate mathematics, the Mathematical Association of America (MAA) was well positioned to seize an opportunity for funding from the National Science Foundation (NSF) to intensify and extend this support. As a result, NSF awarded MAA a half-million dollars for a three-year project "Supporting Assessment in Undergraduate Mathematics" (SAUM) that provided a much-needed stimulus for assessment at the departmental level. The need for such a program is rooted in the various and often conflicting views of assessment stemming from worry about uses of the results, difficulties and complexities of the work, and possible conflicts with traditional practices. Faculty navigating through these views to develop effective assessment programs encounter numerous tensions between alternative routes and limiting tethers that restrict options. Against this background the MAA launched SAUM in January 2002.

The goal of SAUM was to encourage and support faculty in designing and implementing effective programs of assessment of student learning in some curricular block of undergraduate mathematics. SAUM leaders were reasonably sure that many faculty would welcome help with assessment because many colleges and universities were under mandates to develop and implement programs to assess student learning—mandates originating in most cases from external entities such as regional accredit-

Case Studies

Developmental, Quantitative Literacy, and Precalculus Programs

Allegheny College. *Assessing Introductory Calculus and Precalculus Courses.*

Arapahoe Community College. *Mathematics Assessment in the First Two Years.*

Arizona Western College. *Using Assessment to Troubleshoot and Improve Developmental Mathematics.*

Cloud County Community College. *Questions About College Algebra.*

Mount Mary College. *Assessing the General Education Mathematics Courses at a Liberal Arts College for Women.*

Portland State University. *Assessment of Quantitative Reasoning in Applied Psychology.*

Portland State University. *Assessing Quantitative Literacy Needs Across the University.*

San Jose State University. *Precalculus in Transition: A Preliminary Report.*

Virginia Commonwealth University. *An Assessment of General Education Mathematics Courses' Contribution to Quantitative Literacy.*

Mathematics-Intensive Programs.

North Dakota State University. *Developing a Departmental Assessment Program.*

United States Military Academy. *Assessing the Use of Technology and Using Technology to Assess.*

Virginia Tech. *A Comprehensive Assessment Program—Three Years Later.*

Weill Cornell Medical College, Qatar. *Assessment of a New American Program in the Middle East.*

Mathematics Programs to Prepare Future Teachers.

Monmouth University. *Assessment in a Middle School Mathematics Teacher Preparation Program.*

University of Texas at Brownsville and Texas Southernmost College. *Using Practice Tests in Assessment of Teacher Preparation Programs.*

The Undergraduate Major in Mathematics.

American University. *Learning Outcomes Assessment: Stimulating Faculty Involvement Rather Than Dismay.*

Colorado School of Mines. *The Development, Implementation, and Revision of a Departmental Assessment Plan.*

Keene State College. *Assessing Student Oral Presentation of Mathematics.*

Point Loma Nazerene University. *Keeping Assessment Simple.*

Portland State University. *Surveying Majors in Developing a Capstone Course.*

Saint Mary's University of Minnesota. *Assessing Written and Oral Communication of Senior Projects.*

Saint Peter's College. *Assessing the Mathematics Major: A Multifaceted Approach.*

South Dakota State University. *Assessing the Mathematics Major Through a Senior Seminar.*

University of Arkansas, Little Rock. *Assessment of Bachelors' Degree Programs.*

University of Nevada, Reno. *Assessment of the Undergraduate Major Without Faculty Buy-in.*

Washburn University. *Assessing the Mathematics Major With a Bottom-Up Approach.*

ing bodies. Our expectations were accurate. We found many faculty willing to tackle assessment but unenthusiastic and even skeptical about the work.

During the three years of SAUM we promoted assessment to hundreds of faculty in professional forums and worked directly with 68 teams of faculty from 66 colleges or universities in SAUM workshops. The final SAUM workshop—restricted to assessing learning in the major—concludes in January 2006. Most of the 68 teams had two or three members, with two usually attending the workshop sessions. As these teams worked face-to-face at the workshop sessions, as they continued their work back home, and as we promoted assessment to the larger audiences in professional forums, skepticism was evident in lack of enthusiasm and inevitably brought forth arguments against assessment as we were advocating it.

The arguments were basically of two types: tensions and tethers. I use tensions here as forces that mitigate against meaningful and effective assessment, pulling toward easier and less effective models. A common example is the tension between doing assessment that is effective in plumbing the depths of student understanding and doing assessment that is practical and more superficial. Most tethers are ties to past and present practices that are likely to continue and possibly prevent or restrict developing effective assessment. For example, many instructional programs are tied to traditional in-course testing and have no plans to change, placing significant limits on assessment.

Below, I describe some of these assessment tensions and tethers, along with some ways SAUM tried to ease the tensions and untie the tethers. First, however, I will explore SAUM retrospectively and describe how it evolved from a decade of assessment activity by the MAA.

From Awareness to Ownership

The SAUM proposal to NSF was based on an unarticulated progression of steps necessary to get college and university faculty fully committed to meaningful and effective assessment of student learning. The first step is *awareness*, the second, *acceptance*; next comes *engagement*, and finally *ownership*.

SAUM Workshop: January was a good time to be in Phoenix.

First, we aimed to make faculty *aware* of the nature and value of assessment by stimulating thought and discussion. Second, we encouraged *acceptance* through knowledgeable and respected plenary speakers at workshops, and collegial interaction with others interested in and sometimes experienced in assessment. Examples of the plenary presentations, documented on the SAUM website (http://www.maa.org/saum/) are presentations and writings by Lynn Steen and Peter Ewell. Their combined overview of how assessment is positioned in the larger arena of federal, state, and university policies and practices can be surmised from their article *The Four A's: Accountability, Accreditation, Assessment, and Articulation* (Ewell & Steen, 2003). This article is based on a presentation by Peter Ewell at the joint session of Workshops #1 and #2 at Towson University in January 2003.

Peter Ewell was an unexpected and valuable resource at workshops, giving plenary presentations and generously agreeing to consult with individual teams. His broad historical perspective, vast experience in consulting with and advising colleges and universities, and intimate knowledge of policies of accrediting bodies gave teams both encouragement and helpful advice. Further, Peter's view as a non-mathematician was helpful both for his questioning and his knowledge of other disciplines. Peter's expertise was nicely complemented by Lynn Steen's wide experience with mathematics, mathematics education, and mathematics and science policy issues.

Third, we urged workshop participants to *engage* in designing and implementing an assessment program at their home institutions. Face-to-face workshop sessions required exit tickets that were plans for actions until the next face-to-face session. Teams presented these plans to their workshop colleagues and then reported at the next session on what had been done. As noted by Peter Ewell in his evaluator's report (see below), this strategy provided strong incentive for participants to make progress at their own institutions so that they would have something to report at the next session of the workshop.

Finally, we promoted *ownership* by requiring that each team write a case study describing its assessment program or present a paper or poster at a professional meeting. Paper sessions were sponsored by SAUM at MathFest 2003 in Boulder, Colorado and at the 2004 Joint Mathematics Meetings in Phoenix, Arizona. SAUM also sponsored a poster session at Phoenix. The case studies have been published in the new MAA report *Supporting Assessment in Undergraduate Mathematics: Case Studies from a National Project* (Steen *et al*., 2005). An additional paper session is scheduled for the 2006 Joint Mathematics Meetings in San Antonio, Texas.

Background for SAUM

SAUM's background goes back to an MAA long-range planning meeting in the late 1980s. At that meeting I asked what the MAA was going to do regarding the growing movement on assessment that had entered the US higher education scene about a decade earlier. Indicative of the fact that no plans had been made by MAA, I soon found myself as chair of the 12-member Subcommittee on Assessment of MAA's Committee on the Undergraduate Program in Mathematics (CUPM). We were charged with advising MAA members on policies and procedures for assessment of learning in the undergraduate major for the purpose of program improvement. Very few of the subcommittee members had any experience in or knowledge of the kind of assessment we would eventually understand that we needed, and we struggled with the multiple meanings and connotations of the vocabulary surrounding the assessment movement. Nevertheless, we plowed into our work at the summer meeting in Columbus, Ohio, in 1990.

> Although most programs expect to collect data that confirms their current practice, even excellent programs have the potential to improve. By designing assessments most likely to identify areas where improvement is appropriate, programs can continue to get better. Students ultimately benefit from this approach.
>
> —Laurie Hopkins

In retrospect, our work developed in three distinct phases: (1) understanding the assessment landscape that included outspoken opposition to assessment; (2) developing guidelines for assessment; and (3) compiling case studies of assessment programs in mathematics departments. A fourth phase, seen in retrospect, was the extensive faculty awareness and professional development made possible by SAUM.

Two vehicles proved very helpful in Phase 1. First, in 1991, I moderated an e-mail discussion on assessment among fourteen academics (twelve mathematicians and two non-mathematicians) that included four members of the Assessment Subcommittee. Some of the discussants were opposed to assessment as it was then evolving; their worries ranged from operational issues like extra work to fundamental issues like academic freedom. E-mail was neither user-friendly nor regularly read in 1991, and managing the information flow and compiling it into a coherent report was quite challenging. Nonetheless, a report was written and published in *Heeding the Call for Change* (Madison, 1992), edited by Lynn Steen, who had been both helpful and encouraging on my involvement with assessment.

Appended to the report of the 1991 e-mail discussion is a reprint of a seminal article by Grant Wiggins consisting of the text of his 1990 keynote address to the assessment conference of the American Association for Higher Education (Wiggins, 1992). This annual conference began in 1985 and over the past two decades has been the premier convening event on assessment in higher education. Between 1990 and 1995, I attended these conferences, learned about assessment outside mathematics, and eventually mastered the language. Plenary speakers such as Wiggins, Patricia Cross, and Peter Ewell were impressive in their articulate command of such a large academic landscape.

Phase 2 of the work of the Assessment Subcommittee consisted of producing a document on assessment that would both encourage assessment and guide department faculties in their efforts to design and implement assessment programs. Grounded largely in the e-mail discussion and a couple of AAHE assessment conferences, I forged a first draft of guidelines that was based on assessment as a cycle that eventually would have five stages before it repeated. By 1993 the Subcommittee had a draft ready to circulate for comment. Aside from being viewed as simplistic by some because of inattention to research on learning, the guidelines were well received and CUPM approved them in January 1995 (CUPM, 1995).

Further plans of the Subcommittee included gathering case studies as examples to guide others in developing assessment programs. The small number of contributions to two contributed paper sessions that the Subcommittee had sponsored did not bode well for collecting case studies, especially on assessment of learning in the major. However, strong interest and enrollment in mini-courses on assessment indicated that case studies might soon be available. One of the Subcommittee members, William Marion, had expressed interest in teaming up with Bonnie Gold and Sandra Keith to gather and edit case studies on more general assessment of learning in undergraduate mathematics. By agreeing to help these three, I saw the work of the Subcommittee as essentially finished and recommended that we be discharged. The Subcommittee was dissolved, and in 1999 *Assessment Practices in Undergraduate Mathematics* containing seventy-two case studies was published as MAA Notes No. 49, with Gold, Keith, and Marion as editors (Gold, *et al.*, 1999).

Two years later, in 2001, NSF announced the first solicitation of proposals in the new Assessment of Student Achievement program. During two weeks in May 2001 while I was serving as Visiting Mathematician at MAA, with help and encouragement from Thomas Rishel, and with the encouragement and advice from members of CUPM, most notably William Haver, I wrote the proposal for SAUM. I was fortunate to gather together a team for SAUM that included the principals

> Increasingly, accrediting agencies such as ABET (engineering) and NCATE (teacher education) are less interested in the mathematics courses students have taken or the content they have studied than in students' demonstration of mathematical performance. "Demonstrated proficiency" is rapidly replacing named courses.
>
> —Dick Jardine

in MAA's decade of work on assessment: Bonnie Gold, Sandra Keith, William Marion, Lynn Steen, and myself. Good fortune continued when William Haver agreed to direct the SAUM workshops and Peter Ewell agreed to serve as SAUM's evaluator.

In August 2001 I learned that the NSF was likely to fund SAUM for the requested period, January 1, 2002, to December 31, 2004, at the requested budget of $500,000. Because we were reasonably sure of an award, we were able to begin work early, in effect extending the period of the project by several months. The award was made official (DUE 0127694) in fall 2001.

The 1995 CUPM Guidelines on Assessment are reprinted as an appendix to *Assessment Practices in Undergraduate Mathematics* (CUPM, 1995) and an account of MAA's work on assessment is in the foreword (Madison, 1999). A lighter account of my views on encountering and understanding assessment, "Assessment: The Burden of a Name," can be found on the website of Project Kaleidoscope (Madison, 2002).

Tensions and Tethers

As noted above, throughout SAUM and the MAA's assessment work that preceded SAUM, various tensions and tethers slowed progress and prompted long discussions, some of which were helpful. Some faculty teams were able to ease or circumvent the tensions while others still struggle with the opposing forces. Likewise, some were able to free their program of the restraints of certain tethers, while others developed programs within the range allowed.

> Goals for courses below calculus often include some broad skills (e.g. to read a newspaper critically) and some effective outcomes (e.g. to feel less mathophobic). Partner disciplines and committees on general education can provide useful input as mathematics departments define these course goals. Concrete learning objectives can be developed even for effective goals.
>
> —Bonnie Gold

A major obstacle to negotiating these tensions and tethers is the lack of documented success stories for assessment programs. Very few programs have gone through the assessment cycle multiple times and used the results to make changes that result in increased student learning. This absence of success stories requires that faculty work on assessment be based either on faith or on a sense of duty to satisfy a mandate. In theory, the assessment cycle makes sense, but implementation is fraught with possibilities for difficulties and minimal returns. There is, thus, considerable appeal to yield to tensions—to do less work or to work only within the bounds determined by a tether to traditional practice.

> One lesson learned by SAUM participants is to not overwhelm the assessment program with too many procedures or data. Keep assessment simple. To do that it is often prudent to proceed in stages. For example, choose just one goal to pilot test the assessment process. Analyzing results in one area can serve as a prototype for more comprehensive assessment in the future.
>
> —William Marion

Easing Tensions

The most prominent tension in assessment is *between what is practical and what is effective* in judging student performance and understanding. There are several reasons for this, some of which involve other tensions. Multiple-choice, machine-scored tests are practical but not effective in probing the edges and depths of student understanding or for displaying thought processes or misconceptions. Student interviews and open-ended free-response items appear to be more effective in this probing, but are not practical with large numbers of students. We know too little about what is effective and what the practical methods measure, but we believe that getting students to "think aloud" is revealing of how they learn. Unable to see evidence of value in the hard work of effective assessment, we very often rely on the results of practical methods—believing that we are measuring similar or highly correlated constructs.

To ease this tension between the practical and the "impractical," we recommended that faculty start small and grow effective methods slowly. Interviewing a representative sample of students is revealing; comparing the results of these interviews with the results of practical methods can provide valuable information. Knowing how students learn can inform assessment in an essential and powerful way. We know too little about how mathematical concepts are learned, especially in a developmental fashion, and we know too little about how assessment influences instruction. This is both an impediment to doing assessment and a challenging reason for doing it. One can use it as an excuse for waiting until we know more about learning, or one can move ahead guided by experience but alert to evidence of how learning is occurring and how learning and assessment are interconnected.

> One theme that arises repeatedly in assessment programs is the need to account for the culture of the host institution. Assessment can be conducted more readily if it is part of institutional culture. Failing to account for the cultural environment is a common cause of reduced effectiveness of assessment efforts.
>
> —Dick Jardine

Many assessment programs are the result of requirements by accrediting agencies or associations. Often these requirements boil down to applying three or four tools to measure student learning outcomes for majors and for general education. For example, the tools for a major could be a capstone course, exit interviews, and an end-of-program comprehensive examination. Consequently, discipline faculties can meet the requirements by doing minimal work—designating a capstone course, interviewing graduating seniors, and selecting an off-the-shelf major field achievement test—and getting minimal benefits.

Reflecting on the results of the assessment and considering responses such as program or advising changes requires more work and raises questions about past practices. This tension *between getting by with minimal work for minimal payoff and probing deeply to expose possibly intractable problems* does offer pause to faculty whose time is easily allocated to other valued work.

The tension pulling toward meeting mandated assessment requirements minimally is reinforced by the bad reputation that assessment has among faculties. This reputation derives both from worries about uses of assessment results for accountability decisions and from numerous reports of badly designed and poorly implemented large-scale high stakes assessments. Unfortunately, few people understand the broad assessment landscape well enough to help faculty understand that their assessment work has educational value that is largely independent of the public issues that are often used to discredit assessment. Fortunately, in SAUM we did have people who understood this landscape and could communicate it to mathematics faculty.

Mathematicians are confident of their disciplinary knowledge and generally agree on the validity of research results. However, their research paradigm of reasoning logically from a set of axioms and prior research results is not the empirical methodology of educational practice where assessment resides. This tension *between ways of knowing* in very different disciplines often generates disagreements that prompt further evidence gathering and caution in drawing inferences from assessment evidence. Eventually, though, decisions have to be made without airtight proof.

Laurie Hopkins leads a session at a SAUM workshop.

This tension is amplified by the complexity of the whole assessment landscape. For example, the so-called three pillars of assessment—observation, interpretation, and cognition—encompass whole disciplines such as psychometrics and learning theory (NRC, 2001).

Assessment of learning in a coherent block of courses often provides information that can be used to compare learning in individual courses or in sections of a single course, and hence to judge course and instructor effectiveness. Such comparisons and judgments create tension *between individual faculty member's academic freedom and the larger interest of programs.* Indeed, learning goals for a block of courses do place restrictions on the content of courses within the block.

Mathematics faculty members are accustomed to formulating learning goals in terms of mathematical knowledge rather than in terms of student performance in using mathematics. This creates tension *between testing what students know and testing for what students can do.* Since judging student performance is usually far more complex than testing for specific content knowledge, this tension is closely related to that between practical versus effective tension discussed above.

Partly because of the nature of mathematical knowledge, many instructional programs have not gathered empirical evidence of what affects student learning. Rather, anecdotal information—often based on many years of experience with hundreds of students—holds sway, indicative of the tension *between a culture of evidence and a culture of anecdotal experience.* Since empirical evidence is often inconclusive, intuition and experience will be valuable, even more so when bolstered by evidence.

Untying Tethers

Mathematics programs in colleges and universities are very tradition-bound, and many of these traditions work against effective assessment of student learning. Sometimes, these tethers can be untied or loosened; sometimes they cannot. The tethers we encountered in SAUM include:

Tethers to traditional practices in program evaluations. We are accustomed to evaluating programs by the quantity of resources attracted to the program—inputs—as opposed to quality of learning outcomes. One reason for this traditional practice is the lack of evidence about learning outcomes, or even an articulation of what they are.

Tethers to traditional faculty rewards system. Traditionally, mathematics faculty rewards are based on accomplishments that do not include educational or empirical research results much less amorphous scholarship on assessment. Even if scholarship on assessment is recognized and rewarded, the outlets for such work are very limited. Unlike the situation in mathematics research, standards for judging empirical assessment work are not widely agreed to and, consequently, are inconsistent.

Tethers to traditional lecture-style teaching. Especially with large classes, lecture-style teaching severely limits assessment options, especially for formative assessment. Some electronic feedback systems allow lecturers to receive information quickly about student understanding of concepts, but probing for the edges of understanding or for misconceptions requires some other scheme such as interviewing a sample of the students.

Tethers to a traditional curriculum. The traditional college mathematics curriculum is based largely in content, so assessment of learning (including learning goals) has been couched in terms of this content. Standardized testing has centered on this content. Students and faculty expect assessment items to address knowledge of this content. Consequently, there is resistance to less specific assessment items, for example, open-ended ill-posed questions.

Tethers to traditional in-course testing. This tether was very apparent in the work of SAUM workshop teams. Going beyond assessing learning in a single course to assessing learning in a block of courses was a major step for many faculty teams. This step involved a range of issues from developing learning goals for the block to logistical arrangements of when and where to test. Even when learning goals were agreed to, assessing areas such as general education or quantitative literacy offered special challenges.

Recognizing this tether, Grant Wiggins has compared assessment of quantitative literacy to performance of sports. One can practice and even master all the individual skills of basketball, but the assessment of basketball players is based on performances in actual games. Wiggins concludes that assessment for quantitative literacy threatens all mainstream testing and grading in all disciplines, especially mathematics (Wiggins, 2003).

Components of SAUM

SAUM had five components that were aimed at encouraging faculty to design, develop, and implement meaningful assessment programs. The plan, as outlined earlier, was to move faculty in departments of mathematics from awareness of assessment, to acceptance, to engagement, and finally to ownership.

Component 1

The initial component was aimed at stimulating thought and discussion, thereby raising awareness about assessment and why it could be a valuable part of an instructional program. There were three principal vehicles:

- Panels at national and regional professional meetings.
- Ninety-minute forums at meetings of MAA Sections. Forums were held at seventeen of the twenty-nine sections.
- Distributing *Assessment Practices in Undergraduate Mathematics* (Gold *et al.*, 1999) to the chairs of each of the 3000 plus departments of mathematics in two- and four-year colleges or universities in the United States.


SAUM Workshop: Are you sure that will work?

Component 2

A chief project goal was to publish a new volume containing new case studies together with updated case studies from *Assessment Practices in Undergraduate Mathematics*. For reasons that are unclear, few of the original case studies were updated. The project had more success in gathering new case studies, mainly because the workshops provided natural vehicles for generating them.

SAUM originally planned to support six areas of assessment: (i) the undergraduate mathematics major, including those for prospective secondary school mathematics teachers; (ii) general education courses in mathematics and statistics, including those intended to achieve quantitative literacy; (iii) blocks of mathematics courses for prospective elementary or middle school teachers; (iv) placement programs or developmental mathematics courses; (v) reform courses or other innovations; and (iv) classroom assessment of learning.

However, as SAUM developed and workshop teams enrolled, this original list of six areas evolved into five: the major, general education, mathematics for teachers, pre-calculus mathematics, and mathematics in mathematics-intensive majors. Well over half of the sixty-eight SAUM teams worked in just one of these areas—assessment of the major.

Component 3

Development and delivery of four faculty development workshops plus a self-paced online workshop was the central

SAUM workshop director Bill Haver chats with SAUM director Bernie Madison at the SAUM Poster Session at the 2003 Joint Mathematics Meetings in Phoenix.

component of SAUM. As noted above, the workshop teams provided almost all the new case studies and provided a critical audience for selecting resources to support assessment. William Haver was the principal organizer and designer of the SAUM workshops.

Preliminary evidence indicates that the workshops were successful in moving the faculty teams to engagement with assessment and many to ownership. Workshop participants repeatedly told us that the interaction among teams was important, and we relied heavily on this feature to move participants from acceptance to engagement and ownership. Knowledge and experience of workshop leaders and presenters seemed to work for awareness and acceptance but not much further.

We do not have evidence about the effectiveness of the online workshop. Although the suggested readings in the online workshop are selected to move faculty through the awareness, acceptance, engagement, and ownership sequence, face-to-face support and collegial interaction may be an essential ingredient that is missing from the online approach.

Although not specified as a goal in the original SAUM proposal, a significant accomplishment of SAUM was identifying and developing leadership in assessment of learning in undergraduate mathematics. SAUM began with six leaders, none of whom claimed broad expertise in assessment or in conducting workshops for faculty on assessment. Since each workshop session would require four or more leaders or consultants, recruiting new leaders seemed essential.

We were fortunate that in the first and second workshops several leaders emerged. From these leaders we recruited Rick Vaughn (Paradise Valley Community College), William Martin (North Dakota State University), Laurie Hopkins (Columbia College), Kathy Safford-Ramus (St. Peter's College), and Dick Jardine (Keene State College). These new leaders provided experience in assessment at various levels at a variety of institutions and enriched our subsequent workshop sessions by sharing their experiences. Two of the five—Laurie Hopkins and Dick Jardine—assisted with editing the SAUM case studies.

Component 4

Construction of the SAUM website (www.maa.org/saum) began at the outset of the project. The site, part of MAA Online, has several major sections that supported SAUM activities and continue to provide resources for undergraduate mathematics assessment. These include:

- An annotated bibliography on assessment drawn from multiple sources.
- A communication center for SAUM workshops, sessions at national meetings, and section forums.
- Links to dozens of sites that have information on assessment relevant to the goals of SAUM.
- A frequently asked questions (FAQ) section containing brief answers to 32 common questions about assessment.
- The online assessment workshop.
- Online copies of case studies and other papers in *Assessment Practices in Undergraduate Mathematics* (Gold, *et al.*, 1999).
- Draft case studies including exhibits and supporting documents.
- The contents of the SAUM case studies volume, *Supporting Assessment in Undergraduate Mathematics* (Steen, 2005).

Component 5

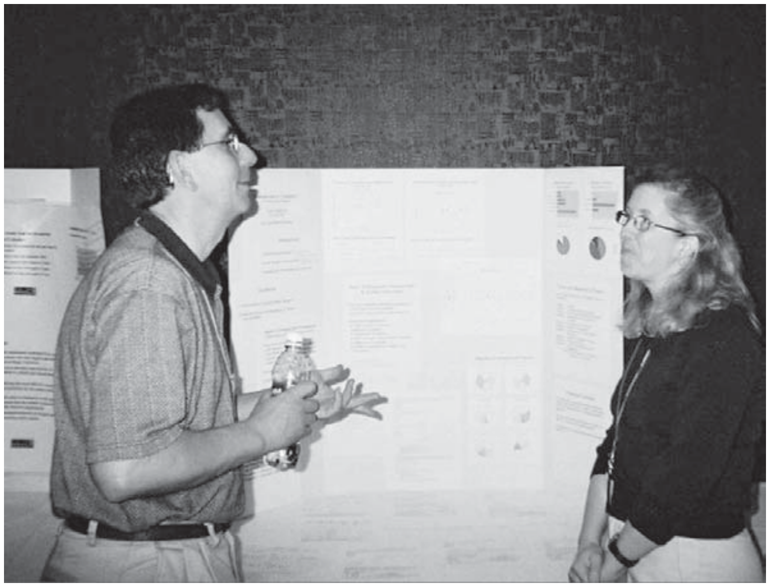
Dissemination of SAUM employs three media—print, electronic, and personal. Products include the SAUM case studies volume and this special report in FOCUS; the SAUM website enumerated above; and presentations at national meetings, so far including 24 contributed papers and 18 poster exhibits.

Beyond SAUM

Through the SAUM workshops, nearly 200 mathematics faculty members participated in the development and implementation of programs of assessment in 66 college and university mathematics departments. In addition, several hundred other faculty became more aware of the challenges and benefits of assessment through other SAUM activities. The SAUM web site (www.maa.org/saum) and the associated volume of case studies (Steen *et al.*, 2005) constitute valuable resources for others interested in assessment.

Nonetheless, the accomplishments of SAUM are probably insufficient to provide a critical mass of experience and understanding necessary for assessment to become a natural part of instructional programs in most mathematics departments. Because assessment is largely alien to beliefs of many mathematics faculty and to traditions in most mathematics departments, much further work will be needed to overcome the tensions and untie the tethers discussed here.

Increased external demands for accountability for student learning will keep faculty attentive but still unenthusiastic about assessment. Only success stories that are documented to the satisfaction of skeptical mathematicians will break through the tacit resistance and cause faculty to take ownership of and work diligently on assessment programs. Perhaps some of the SAUM-inspired programs will provide these stories. In addition, support from MAA for assessment in undergraduate mathematics will likely be needed for years to come.



SAUM Poster Session: This is what we did, and here is what we found out.

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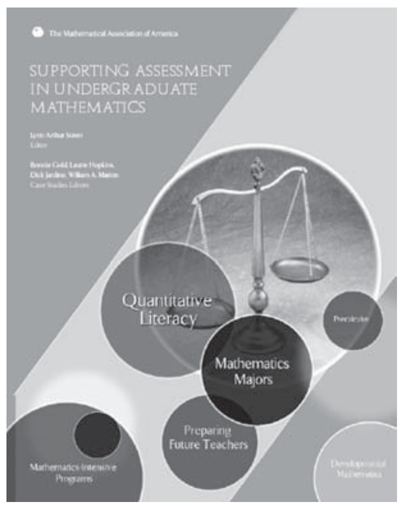

A complimentary copy of the new SAUM report is available to the first 1000 departments submitting requests through the project website http://www.maa.org/saum, *where you can also access the full text of the report.*

Asking the Right Questions

By Lynn Arthur Steen

Assessment is about asking and answering questions. For students, "how am I doing?" is the focus of so-called "formative" assessment, while "what's my grade?" often seems to be the only goal of "summative" assessment. For faculty, "how's it going?" is the hallmark of within-course assessment using instruments such as ten-minute quizzes or one-minute responses on 3 x 5 cards at the end of each class period. Departments, administrations, trustees, and legislators typically ask questions about more aggregated levels: they want to know not about individual students but about courses, programs, departments, and entire institutions.

The conduct of an assessment depends importantly on who does the asking and who does the answering. Faculty are accustomed to setting the questions and assessing answers in a context where outcomes count for something. When assessments are set by someone other than faculty, skepticism and resistance often follow. And when tests are administered for purposes that don't "count," (for example, sampling to assess general education or to compare different programs), student effort declines and results lose credibility.

The assessment industry devotes considerable effort to addressing a variety of similar contextual complications, such as:

- different purposes (diagnostic, formative, summative, evaluative, self-assessment, ranking);
- different audiences (students, teachers, parents, administrators, legislators, voters);
- different units of analysis (individual, class, subject, department, college, university, state, nation);
- different types of tests (multiple choice, open ended, comprehension, performance-based, timed or untimed, calculator permitted, individual or group, seen or unseen, external, written or oral);
- different means of scoring (norm-referenced, criterion referenced, standards-based, curriculum-based);
- different components (quizzes, exams, homework, journals, projects, presentations, class participation);
- different standards of quality (consistency, validity, reliability, alignment);

SAUM Workshop: This plan must be finished before we go home.

- different styles of research (hypothesis-driven, ethnographic, comparative, double-blind, epidemiological).

Distinguishing among these variables provides psychometricians with several lifetimes' agenda of study and research. All the while, these complexities cloud the relation of answers to questions and weaken inferences drawn from resulting analyses.

These complications notwithstanding, questions are the foundation on which assessment rests. The assessment cycle begins with and returns to goals and objectives (CUPM, 1995). Translating goals into operational questions is the most important step in achieving goals since without asking the right questions we will never know how we are doing.

Two Examples

In recent years two examples of this truism have been in the headlines. The more visible—because it affects more people—is the new federal education law known as No Child Left Behind (NCLB). This law seeks to ensure that every child is receiving a sound basic education. With this goal, it requires assessment data to be disaggregated into dozens of different ethnic and economic categories instead of typical analyses that report only single averages. NCLB changes the question that school districts need to answer from "What is your average score?" to "What are the averages of every subgroup?" Theoretically, to achieve its titular purpose, this law would require districts to monitor every child according to federal standards. The legislated requirement of multiple subgroups is a political and statistical compromise between theory and reality. But even that much has stirred up passionate debate in communities across the land.

A related issue that concerns higher education has been simmering in Congress as it considers reauthorizing the law that, among other things, authorizes federal grants and loans for postsecondary education. In the past, in exchange for these grants and loans, Congress asked colleges and universities only to demonstrate that they were exercising proper stewardship of these funds. Postsecondary institutions and their accrediting agencies provided this assurance through financial audits to ensure lack of fraud and by keeping default rates on student loans to an acceptably low level.

But now Congress is beginning to ask a different question. If we give you money to educate students, they say, can you show us that you really are educating your students? This is a new question for Congress to ask, although it is one that deans, presidents, and trustees should ask all the time. The complexities of assessment immediately jump to the foreground. How do you measure the educational outcomes of a college education? As important, what kinds of assessments would work effectively and fairly for all of the 6,600 very different kinds of postsecondary institutions in the United States, ranging from 200-student beautician schools to 40,000-student research universities? Indicators most often discussed include the rates at which students complete their degrees or the rates at which graduates secure professional licensing or certification. In sharp contrast, higher education mythology still embraces James Garfield's celebrated view of education as a student on one end of a log with Mark Hopkins on the other end. In today's climate of public accountability, colleges and universities need to "make peace" with citizens' demand for candor and openness anchored in data (Ekman, 2004).

I cite these examples to make two points. First, the ivory tower no longer shelters education from external demands for accountability. Whether faculty like it or not, the public is coming to expect of education the same kind of transparency that it is also beginning to demand of government and big business. Especially when public money is involved—as it is in virtually every educational institution—public questions will follow.

Second, questions posed by those outside academe are often different from those posed by educators, and often quite refreshing. After all these years in which school districts reported and compared test score averages, someone in power finally said "but what about the variance?" Are those at the bottom within striking distance of the average, or are they hopelessly behind with marks cancelled out by accelerated students at the top? And after all these years of collecting tuition and giving grades, someone in power has finally asked colleges and universities whether students are receiving the education they and the public paid for. Asking the right questions can be a powerful lever for change, and a real challenge to assessment.

Mathematics

One can argue that mathematics is the discipline most in need of being asked the right new questions. At least until very recently, in comparison with other school subjects mathematics has changed least in curriculum, pedagogy, and assessment. The core of the curriculum in grades 10-14 is a century-old enterprise centered on algebra and calculus, embroidered with some old geometry and new statistics. Recently, calculus passed through the gauntlet of reform and emerged only slightly refurbished. Algebra—at least that part known incongruously as "College Algebra"—is now in line for its turn at the reform carwash. Statistics is rapidly gaining a presence in the lineup of courses taught in grades 10-14, although geometry appears to have lost a bit of the curricular status that was provided by Euclid for over two millennia.

When confronted with the need to develop an assessment plan, mathematics departments generally take this traditional curriculum for granted and focus instead on how to help students through it. However, when they ask for advice from other departments, mathematicians are often confronted with rather different questions (Ganter & Barker, 2004):

- *Do students in introductory mathematics courses learn a balanced sample of important mathematical tools?*
- *Do these students gain the kind of experience in modeling and communication skills needed to succeed in other disciplines?*
- *Do they develop the kind of balance between computational skills and conceptual understanding appropriate for their long-term needs?*

Greece, 250 BCE

If thou art diligent and wise, O stranger, compute the number of cattle of the Sun, who once upon a time grazed on the fields of the Thrinacian isle of Sicily, divided into four herds of different colours, one milk white, another a glossy black, a third yellow and the last dappled. In each herd were bulls, mighty in number according to these proportions: Understand, stranger, that the white bulls were equal to a half and a third of the black together with the whole of the yellow, while the black were equal to the fourth part of the dappled and a fifth, together with, once more, the whole of the yellow. Observe further that the remaining bulls, the dappled, were equal to a sixth part of the white and a seventh, together with all of the yellow. These were the proportions of the cows: The white were precisely equal to the third part and a fourth of the whole herd of the black; while the black were equal to the fourth part once more of the dappled and with it a fifth part, when all, including the bulls, went to pasture together. Now the dappled in four parts were equal in number to a fifth part, and a sixth of the yellow herd. Finally the yellow were in number equal to a sixth part, and a seventh of the white herd. If thou canst accurately tell, O stranger, the number of cattle of the Sun, giving separately the number of well-fed bulls and again the number of females according to each colour, thou wouldst not be called unskilled or ignorant of numbers, but not yet shalt thou be numbered among the wise.

But come, understand also all these conditions regarding the cattle of the Sun. When the white bulls mingled their number with the black, they stood firm, equal in depth and breadth, and the plains of Thrinacia, stretching far in all ways, were filled with their multitude. Again, when the yellow and the dappled bulls were gathered into one herd they stood in such a manner that their number, beginning from one, grew slowly greater till it completed a triangular figure, there being no bulls of other colours in their midst nor none of them lacking. If thou art able, O stranger, to find out all these things and gather them together in your mind, giving all the relations, thou shalt depart crowned with glory and knowing that thou hast been adjudged perfect in this species of wisdom.

—Archimedes, *Counting the Cattle of the Sun*

- *Why can't more mathematics problems employ units and realistic measurements that reflect typical contexts?*

These kinds of questions from mathematics' client disciplines strongly suggest the need for multi-disciplinary participation in mathematics departments' assessment activities.

Similar issues arise in relation to pedagogy, although here the momentum of various "reform" movements of the last two decades (in using technology, in teaching calculus, in setting K-12 standards) has energized considerable change in mathematics instruction. Although lectures, problem sets, hour tests, and final exams remain the norm for mathematics teaching, innovations involving calculators, computer packages, group projects, journals, and various mentoring systems have enriched the repertoire of postsecondary mathematical pedagogy. Many assessment projects seek to compare these new methods with traditional approaches. But client disciplines and others in higher education press even further:

- *Do students learn to use mathematics in interdisciplinary or "real-world" settings?*
- *Are students encouraged (better still, required) to engage mathematics actively in ways other than through routine problem sets?*
- *Do mathematics courses leave students feeling empowered, informed, and responsible for using mathematics as a tool in their lives?* (Ramaley, 2003)

Prodded by persistent questions, mathematicians have begun to think afresh about content and pedagogy. In assessment however, mathematics still seems firmly anchored in hoary traditions. More than most disciplines, mathematics is defined by its problems and examinations, many with histories that are decades or even centuries old. National and international mathematical Olympiads, the William Lowell Putnam undergraduate exam, the Cambridge University mathematics Tripos, not to mention popular problems sections in most mathematics education periodicals attest to the importance of problems in defining the subject and identifying its star pupils. The correlation is far from perfect: not every great mathematician is a great problemist, and many avid problemists are only average mathematicians. Some, indeed, are amateurs for whom problem solving is their only link to a past school love. Nonetheless, for virtually everyone associated with mathematics education, assessing mathematics means asking students to solve problems.

China, 100 CE

• A good runner can go 100 paces while a poor runner covers 60 paces. The poor runner has covered a distance of 100 paces before the good runner sets off in pursuit. How many paces does it take the good runner before he catches up to the poor runner?

• A cistern is filled through five canals. Open the first canal and the cistern fills in 1/3 day; with second, it fills in 1 day; with the third, in 2 1/2 days; with the fourth, in 3 days, and with the fifth in 5 days. If all the canals are opened, how long will it take to fill the cistern?

• There is a square town of unknown dimensions. There is a gate in the middle of each side. Twenty paces outside the North Gate is a tree. If one leaves the town by the South Gate, walks 14 paces due south, then walks due west for 1775 paces, the tree will just come into view. What are the dimensions of the town?

• There are two piles, one containing 9 gold coins and the other 11 silver coins. The two piles of coins weigh the same. One coin is taken from each pile and put into the other. It is now found that the pile of mainly gold coins weighs 13 units less than the pile of mainly silver coins. Find the weight of a silver coin and of a gold coin.

—*Nine Chapters on the Mathematical Art.*

Mathematical Problems

Problems on mathematics exams have distinctive characteristics that are found nowhere else in life. They are stated with precision intended to ensure unambiguous interpretation. Many are about abstract mathematical objects—numbers, equations, geometric figures—with no external context. Others provide archetype contexts that are not only artificial in setting (e.g., rowing boats across rivers) but often fraudulent in data (invented numbers, fantasy equations). In comparison with problems people encounter in their work and daily lives, most problems offered in mathematics class, like shadows in Plato's allegorical cave, convey the illusion but not the substance of reality.

Little has changed over the decades or centuries. Problems just like those of today's texts (only harder) appear in manuscripts from ancient Greece, India, and China (see sidebars). In looking at undergraduate mathematics exams from 100 or 150 years ago, one finds few surprises. Older exams typically include more physics than do exams of today, since in earlier years these curricula were closely linked. Mathematics course exams from the turn of the twentieth century required greater virtuosity in accurate lengthy calculations. They were, after all, set for only 5% of the population, not the 50% of today. But the central substance of the mathematics tested and the distinctive rhetorical nature of problems are no different from typical problems found in today's textbooks and mainstream exams.

Questions suitable for a mathematics exam are designed to be unambiguous, to have just one correct answer (which may consist of multiple parts), and to avoid irrelevant distractions such as confusing units or complicated numbers. Canonical problems contain enough information and not an iota more than what is needed to determine a solution. Typical tests are time-constrained and include few problems that students have not seen before; most tests have a high proportion of template problems whose types students have repeatedly practiced. Mathematician and assessment expert Ken Houston of the University of Ulster notes that these types of mathematics tests are a "rite of passage" for students around the world, a rite, he adds, that is "never to be performed again" once students leave university. Unfortunately, Houston writes, "learning mathematics for the principal purpose of passing examinations often leads to surface learning, to memory learning alone, to learning that can only see small parts and not the whole of a subject, to learning wherein many of the skills and much of the knowledge required to be a working mathematician are overlooked" (Houston, 2001).

All of which suggests a real need to assess mathematics assessment. Some issues are institutional:

- *Do institutions include mathematical or quantitative proficiency among their educational goals?*
- *Do institutions assess the mathematical proficiency of all students, or only of mathematics students?*
- *Others are more specifically mathematical:*
- *Can mathematics tests assess the kinds of mathematical skills that society needs and values?*
- *What kinds of problems would best reflect the mathematical needs of the average educated citizen?*
- *Can mathematics faculty fairly assess the practice of mathematics in other disciplines? Should they?*

Issues and Impediments

Assessment has had a tenuous impact in higher education, especially among mathematicians who are trained to demand rigorous inferences that are rarely attainable in educational assessment. Some mathematicians are unrelentingly critical of any educational research that does not closely approach medicine's gold standard of randomized, double blind, controlled, hypothesis-driven studies. Their fears are not unwarranted. For example, a recent federal project aimed at identifying high quality educational studies found that only one of 70 studies of middle school mathematics curricula met the highest standards for evidence (What Works, 2005). Virtually all assessment studies undertaken by mathematics departments fall far short of mathematically rigorous standards and are beset by problems such as confounding factors and attrition. Evidence drawn entirely from common observational studies can never do more than suggest an hypothesis worth testing through some more rigorous means.

Notwithstanding skepticism from mathematicians, many colleges have invested heavily in assessment; some have even made it a core campus philosophy. In some cases this special focus has led these institutions to enhanced reputations and improved financial circumstances. Nonetheless, evidence of the relation between formal assessment programs and quality education is hard to find. Lists of colleges that are known for their commitment to formal assessment programs and those in demand for the quality of their undergraduate education are virtually disjoint.

Institutions and states that attempt to assess their own standards rigorously often discover large gaps between rhetoric and reality. Both in secondary and postsecondary education, many students fail to achieve the rhetorical demands of high standards. But since it is not politically or emotionally desirable to brand so many students as failures, institutions find ways to undermine or evade evidence from the assessments. For example, a recent study shows that on average, high stakes secondary school exit exams are pegged at the 8th and 9th grade level to avoid excessive failure rates (Achieve, 2004). Higher education typically solves its parallel problem either by not assessing major goals or by doing so in a way that is not a requirement for graduation.

- *How, if at all, are the mathematical, logical, and quantitative aspects of an institution's general education goals assessed?*
- *How can the goals of comprehending and communicating mathematics be assessed?*

When mathematicians and test experts do work together to develop meaningful assessment instruments, they confront major intellectual and technical hurdles. First are issues about the harmony of educational and public purposes:

- *Can a student's mathematical proficiency be fairly measured along a single dimension?*
- *What good is served by mapping a multifaceted profile of strengths and weaknesses into a single score?*

Clearly there are such goods, but they must not be oversold. They include facilitating the allocation of scarce educational resources, enhancing the alignment of graduates with careers, and —with care—providing data required to properly manage educational programs. They do not (and thus should not) include firm determination of a student's future educational or career choices. To guard against misuse, we need always to ask and answer:

- *Who benefits from the assessment?*
- *Who are the stakeholders?*
- *Who, indeed, owns mathematics?*

Mathematical performance embraces many different cognitive activities that are entirely independent of content. If content such as algebra and calculus represents the nouns—the "things" of mathematics—cognitive activities are the verbs: know, calculate, investigate, invent, strategize, critique, reason, prove, communicate, apply, generalize. This varied landscape of performance expectations opens many questions about the

India, 400 CE

• One person possesses seven asava horses, another nine haya horses, and another ten camels. Each gives two animals, one to each of the others. They are then equally well off. Find the price of each animal and the total value of the animals possessed by each person.

• Two page-boys are attendants of a king. For their service one gets 13/6 dinaras a day and the other 3/2. The first owes the second 10 dinaras. Calculate and tell me when they have equal amounts.

—*The Bakhsali Manuscript*

purpose and potential of mathematics examinations. For example:

- *Should mathematics exams assess primarily students' ability to perform procedures they have practiced or their ability to solve problems they have not seen before?*
- *Can ability to use mathematics in diverse and novel situations be inferred from mastery of template procedures?*
- *If learned procedures dominate conceptual reasoning on tests, is it mathematics or memory that is really being assessed?*

Reliability and Validity

A widely recognized genius of American higher education is its diversity of institutions: students' goals vary, institutional purposes vary, and performance standards vary. Mathematics, on the other hand, is widely recognized as universal; more than any other subject, its content, practices, and standards are the same everywhere. This contrast between institutional diversity and discipline universality triggers a variety of conflicts regarding assessment of undergraduate mathematics.

Assessment of school mathematics is somewhat different from the postsecondary situation. Partly because K-12 education is such a big enterprise and partly because it involves many legal issues, major assessments of K-12 education are subject to many layers of technical and scholarly review. Items are reviewed for, among other things, accuracy, consistency, reliability, and (lack of) bias. Exams are reviewed for balance, validity, and alignment with prescribed syllabi or standards. Scores are reviewed to align with expert expectations and desirable psychometric criteria. The results of regular assessments are themselves assessed to see if they are confirmed by subsequent student performance. Even a brief examination of the research arms of major test producers such as ETS, ACT, or McGraw Hill reveal that extensive analyses go into preparation of educational tests.

In contrast, college mathematics assessments typically reflect instructors' beliefs about subject priorities more than any external benchmarks or standards of quality. This difference in methodological care between major K-12 assessments and those that students encounter in higher education cannot be justified on the grounds of differences in the "stakes" for students. Sponsors of the SAT and AP exams take great pains to ensure quality control in part because the consequences of mistakes on students' academic careers are so great. The consequences for college students of unjustified placement procedures or unreliable final course exams are just as great.

- *Are "do-it-yourself" assessment instruments robust and reliable?*
- *Can externally written ("off the shelf") assessment instruments align appropriately with an institution's distinctive goals?*
- *Can locally written exams that have not been subjected to rigorous reviews for validity, reliability, and alignment produce results that are valid, reliable, and aligned with goals?*

Professional test developers go to considerable and circuitous lengths to score exams in a way that achieves certain desirable results. For example, by using a method known as "item response theory" they can arrange the region of scores with largest dispersion to surround the passing (so-called "cut") score. This minimizes the chance of mistaken actions based on passing or failing at the expense of decreased reliability, say, of the difference between B+ and A- (or its numerical equivalent).

- *How are standards of performance—grades, cut-scores—set?*
- *Is the process of setting scores clear and transparent to the test-takers?*
- *Is it reliable and valid?*

SAUM Workshop: Laurie Hopkins watches as small groups work.

Without the procedural checks and balances of the commercial sector, undergraduate mathematics assessment is rather more like the Wild West—a libertarian free-for-all with few rules and no established standards of accountability. In most institutions, faculty just make up tests based on a mixture of experience and hunch, administer them without any of the careful reviewing that is required for development of commercial tests, and grade them by simply adding and subtracting arbitrarily assigned points. These points translate into grades (for courses) or enrollments (for placement exams) by methods that can most charitably be described as highly subjective.

Questions just pour out from any thoughtful analysis of test construction. Some are about the value of individual items:

- *Can multiple choice questions truly assess mathematical performance ability or only some correlate? Does it matter?*
- *Can open response tasks be assessed with reliability sufficient for high-stakes tests?*
- *Can problems be ordered consistently by difficulty?*

> In most institutions, courses below calculus—including developmental, quantitative literacy, and precalculus courses—constitute the major part of a mathematics department's workload. Nonetheless, they are not where faculty invest their greatest efforts. They are the least mathematically interesting courses offered by the department, are filled with unenthusiastic students who dislike and fear mathematics, and are often the most difficult and frustrating courses to teach. As a result, however, these are courses in which effective assessment can yield the greatest improvement in both student learning and faculty working conditions.
>
> —Bonnie Gold

- *Is faculty judgment of problem difficulty consistent with empirical evidence from student performance?*
- *What can be learned from easy problems that are missed by good students?*

Others are about the nature and balance of tests that are used in important assessments:

- *Is the sampling of content on an exam truly representative of curricular goals?*
- *Is an exam well balanced between narrow items that focus on a single procedure or concept and broad items that cut across domains of mathematics and require integrated thinking?*
- *Does an assessment measure primarily what is most important to know and be able to do, or just what is easiest to test?*

Interpreting test results

Public interest in educational assessment focuses on numbers and scores—percent passing, percent proficient, percent graduating. Often dismissed by educators as an irrelevant "horse race," public numbers that profile educational accomplishment shape attitudes and, ultimately, financial support. K-12 is the major focus of public attention, but as we have noted, pressure to document the performance of higher education is rising rapidly.

Testing expert Gerald Bracey warns about common misinterpretations of test scores, misinterpretations to which politicians and members of the public are highly susceptible (Bracey, 2004). One arises in comparative studies of different programs. Not infrequently, results from classes of different size are averaged to make overall comparisons. In such cases, differences between approaches may be entirely artificial, being merely artifacts created by averaging classes of different sizes.

Comparisons are commonly made using the rank order of students on an assessment (for example, the proportion from a trial program who achieve a proficient level). However, if many students are bunched closely together, ranks can significantly magnify slight differences. Comparisons of this sort can truly make a mountain out of a molehill.

Another of Bracey's cautions is of primary importance for K-12 assessment, but worth noting here since higher education professionals play a big role in developing and assessing K-12 mathematics curricula. It is also a topic subject to frequent distortion in political contests. The issue is the interpretation of nationally normed tests that report percentages of students who read or calculate "at grade level." Since grade level is defined to be the median of the group used to norm the test, an average class (or school) will have half of its students functioning below grade level and half above. It follows that if 30% of a school's eighth grade students are below grade level on a state mathematics assessment, contrary to frequent newspaper innuendos, that may be a reason for cheer, not despair.

Bracey's observations extend readily to higher education as well as to other aspects of assessment. They point to yet more important questions:

- *To what degree should results of program assessments be made public?*
- *Is the reporting of results appropriate to the unit of analysis (student, course, department, college, state)?*
- *Are the consequences attached to different levels of performance appropriate to the significance of the assessment?*

Program Assessment

As assessment of student performance should align with course goals, so assessment of programs and departments should align with program goals. But just as mathematics' deep attachment to traditional problems and traditional tests often undermines effective assessment of contemporary performance goals, so departments' unwitting attachment to traditional curriculum goals may undermine the potential benefits of thorough, "gloves off" assessment. Asking "how can we improve what we have been doing?" is better than not asking at all, but all too often this typical question masks an assumed *status quo* for goals and objectives. Useful assessment needs to begin by asking questions about goals.

> An effective assessment plan must be anchored in the department's mission statement. So department faculty should first review and update (or if necessary, write) their mission statement. Goals for student learning—broad descriptions of competencies or skills students should achieve—are based on the department's mission. After goals have been articulated, learning objectives—measurable outcomes that tell when a goal has been achieved (or not)—can be developed.
>
> —William Marion

Many relevant questions can be inferred from *Curriculum Guide 2004,* a report prepared recently by MAA's Committee on the Undergraduate Program in Math-

SAUM Workshop: That sounds like a good idea.

ematics (CUPM, 2005). Some questions—the first and most important—are about students:

- *What are the aspirations of students enrolled in mathematics courses?*
- *Are the right students enrolled in mathematics, and in the appropriate courses?*
- *What is the profile of mathematical preparation of students in mathematics courses?*

Others are about placement, advising, and support:

- *Are students taking the best kind of mathematics to support their career goals?*
- *Are students who do not enroll in mathematics doing so for appropriate reasons?*

Still others are about curriculum:

- *Do program offerings reveal the breadth and interconnections of the mathematical sciences?*
- *Do introductory mathematics courses contain tools and concepts that are important for all students' intended majors?*
- *Can students who complete mathematics courses use what they have learned effectively in other subjects?*
- *Do students learn to comprehend mathematically-rich texts and to communicate clearly both in writing and orally?*

A consistent focus of this report and its companion "voices of partner disciplines" (mentioned above) is that the increased spread of mathematical methods to fields well beyond physics and engineering requires that mathematics departments promote interdisciplinary cooperation both for faculty and students. Mathematics is far from the only discipline that relies on mathematical thinking and logical reasoning.

How is mathematics used by other departments?
Are students learning how to use mathematics in other subjects?
Do students recognize similar mathematical concepts and methods in different contexts?

Creating a Culture of Assessment

Rarely does one find faculty begging administrators to support assessment programs. For all the reasons cited above, and more, faculty generally believe in their own judgments more than in the results of external exams or structured assessments. So the process by which assessment takes root on campus is more often more top down than bottom up.

A culture of assessment appears to grow in stages (North Central Assoc., 2002). First is an articulated commitment involving an intention that is accepted by both administrators and faculty. This is followed by a period of mutual exploration by faculty, students, and administration. Only then can institutional support emerge conveying both resources (financial and human) and structural changes necessary to make assessment routine and automatic. Last should come change brought about by insights gleaned from the assessment. And then the cycle begins anew.

Faculty who become engaged in this process can readily interpret their work as part of what Ernest Boyer called the "scholarship of teaching," (Boyer, 1990) thereby avoiding the fate of what Lee Shulman recently described as "drive-by teachers" (Shulman, 2004). Soon they are asking some troubling questions:

- *Do goals for student learning take into account legitimate differences in educational objectives ?*
- *Do faculty take responsibility for the quality of students' learning?*
- *Is assessment being used for improvement or only for judgment?*

> Courses in quantitative literacy are specially well suited to alternative assessment methods such as portfolios, journals, projects, group work, essays, and student-created problems. However, to use these alternative methods efficiently, faculty must establish rubrics to enable readers to summarize diffuse information rapidly and in ways that give useful information and that can be compared across courses.
>
> —Bonnie Gold

Notwithstanding numerous impediments, assessment *is* becoming a mainstream part of higher education programs, scholarship, and literature. In collegiate mathematics, however, assessment is still a minority culture beset by ignorance, prejudice, and the power of a dominant discipline backed by centuries of tradition. Posing good questions is an effective response, especially to mathematicians who pride themselves on their ability to solve problems. The key to convincing mathematicians that assessment is worthwhile is not to show that it has all the answers but that it is capable of asking the right questions.

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Assessing Assessment
The Evaluator's Perspective

By Peter Ewell

The SAUM project took place within a broader context of assessment in American higher education. Faculty teams in mathematics departments experienced in microcosm what their colleagues in many other disciplines were simultaneously experiencing, and their actions were shaped by larger forces of politics and accountability affecting their institutions. At the same time, their efforts to develop and document viable department-level approaches to assessment in mathematics helped inform the national assessment movement—a field badly in need of concrete, discipline-level examples of good practice. Evaluation of SAUM helped bridge these two worlds.

In my personal role as project evaluator, I continued to participate in national conversations about assessment's purposes and prospects throughout the three-year grant period. But watching SAUM participants struggle with the day-to-day reality of crafting workable assessment approaches in their own departments helped keep me honest about what could and could not be accomplished. Similarly, the participant experiences that were revealed through the evaluation information we compiled often mirrored what was happening to other "early adopters" elsewhere.

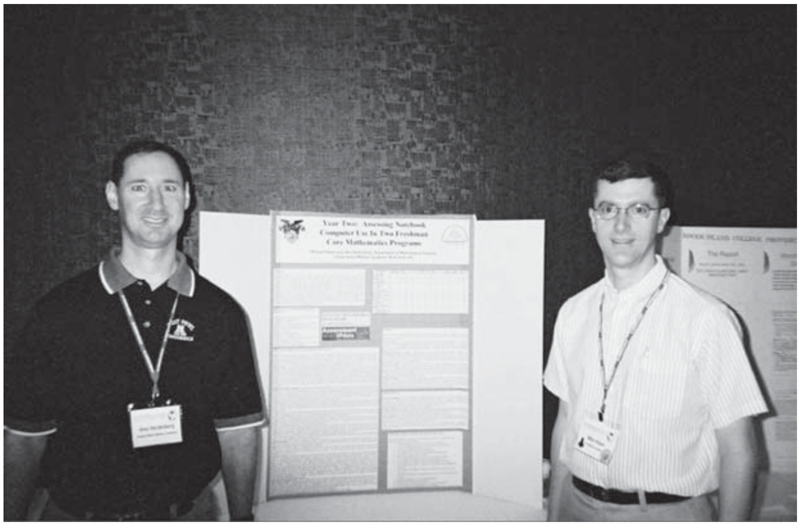
The first section of this essay sets the wider stage for SAUM by locating the project in a national context of assessment. A second section reflects on my role as project evaluator, and describes the kinds of evaluative information we collected to examine the project's activities and impact. A third section presents some of what we learned—focused primarily on what participants told us about how they experienced the project and the challenges they faced in implementing assessment initiatives back home.

SAUM in a National Context

The so-called "assessment movement" in higher education began in the mid-1980s with the confluence of two major forces. One originated inside the academy, prompted by growing concerns about curricular coherence and the conviction that concrete information about how and how well students were learning could be collectively used by faculty to improve teaching and learning (NIE, 1984). This version of "assessment" was low-stakes, incremental, faculty-owned, and guided by a metaphor of scholarship. The other driving force for assessment originated outside the academy prompted by policymakers' growing concerns about the productivity and effectiveness of colleges and universities (NGA, 1986). This version of "assessment" was high-stakes, publicly visible, accountability-oriented, and infused with the urgency of K 12 reform embodied in *A Nation at Risk* (USDOE, 1983).

Although fundamentally contradictory, both these forces were needed to launch and sustain a national movement. External authorities—first in the guise of states and later in the guise of regional accrediting organizations—served to constantly keep assessment at the forefront of institutional attention. But because these external requirements were at first fairly benign—and because academic leaders quickly saw the need to protect the academy's autonomy by developing locally-owned processes that might actually be useful—internal preferences for diverse evidence-gathering approaches aimed at institutional improvement served to discharge accountability as well for many years (Ewell, 1987).

The environment within which the SAUM project was launched was shaped by fifteen years of growing institutional experience with steering between these contradictory poles of assessment. By 2000, virtually every institution could claim that it "did assessment," at least in the sense that it had developed learning outcomes goals for general education and that it periodically surveyed its students and graduates. Most could also point to the beginnings of an institution-level organizational infrastructure for assessment—a coordinator operating out of the academic affairs office perhaps, or a faculty-staffed institutional assessment committee. About a third could lay claim to more sophisticated efforts including testing programs in general education, portfolios assembled by students and organized around general learning outcomes like "effective communication" or "critical thinking," or specially-designed assignments intended to both grade students individually and provide faculty with broader information about patterns of student strength and weakness in various abilities. Indeed, as revealed by the programs at such gatherings as the annual Assessment Forum hosted by the American Association for Higher Education (AAHE), there was a steady increase in the sophistication of institutional assessment efforts with respect to method and approach throughout this period, and equally steady progress in faculty acceptance of the fact that assessment was a part of what colleges and universities, for whatever reason, had to do.



SAUM Poster Session: The United States Military Academy's poster is in good hands.

By 2000, moreover, the primary reason why institutions had to "do assessment" had become regional accreditation. State mandates for assessment in public institutions, instituted in the wake of the National Governors Association's *Time for Results* report in the mid-1980s, had lost a lot of steam in the recession that appeared about 1990. States had other things to worry about and there were few resources to pursue existing mandates in any case. Accreditors, meanwhile, were under mounting pressure by federal authorities to increase their focus on student learning outcomes. Regional accrediting organizations must be "recognized" by the U.S. Department of Education in order for accredited status to serve as a gatekeeper for receipt of federal funds. The federal recognition process involves a regular review of accreditation standards and practices against established guidelines. And since 1989 these guidelines have emphasized the assessment of learning outcomes more forcefully each time they have been revised by the Department. Accreditors are still accorded the leeway to allow institutions to develop their own learning outcomes and to assess them in their own ways. But by 2002, when SAUM was launched, it was apparent that accreditors could no longer afford to allow institutions to get by with little or no assessment—which had up to then essentially been the case—if they hoped to maintain their recognized status. The result was growing pressure on institutions to get moving on assessment, together with growing awareness among institutional academic leaders that a response was imperative.

But even at this late date, assessment remained something distant and faintly "administrative" for the vast majority of college faculty. It was rarely an activity departments engaged in regularly outside professional fields like engineering, education, business, or the health professions where specialized accreditation requirements made assessment mandatory. And even in these cases, the fact that deans and other academic administrators were front and center in the process, complete with the requisite guidelines, memos, schedules, and reports—all written in passive prose—made it likely that faculty in departments like mathematics would keep their distance. At the same time, despite their growing methodological prowess, few institutions were able to effectively "close the loop" by using assessment results in decision-making or to improve instruction. Periodic assessment reports were distributed, to be sure, but most of them ended up on shelves to be ritually retrieved when external visitors inquiring about the topic arrived on campus. Much of the reason for this phenomenon, in hindsight, is apparent. Assessment findings tend to be fine-grained and focused, while institutional decisions remain big and messy. *Real* application required smaller settings, located much closer to the teaching and learning situations that assessment could actually inform.

In this context, the notion of grounding assessment in the individual disciplines where faculty professionally lived and worked made a great deal of sense. For one thing, assessment practitioners had discovered that methods and approaches ought appropriately to vary substantially across fields and that such purportedly "generic" academic abilities as "critical thinking" and "communication" were manifest (and thus had to be assessed) very differently in different disciplinary contexts. At the disciplinary level, moreover, learning outcomes were generally much more easily specified than at the institutional level where of necessity they had to be so broadly cast that they often lost their meaning. More importantly, faculty tended to listen to one another more carefully in disciplinary communities bound by common languages and familiar hierarchies of respect. Even when assessment leaders on campus were faculty instead of administrators, their obvious background in methods derived from education and the social sciences often distanced them from colleagues in the sciences, humanities, fine and performing arts—as well as mathematics. For all these reasons, anchoring assessment in individual disciplinary communities was critical if it was to become a meaningful activity for faculty.

But why mathematics? In my view, mathematics became an "early adopter" of assessment for at least three reasons. First, the discipline is embedded in multiple aspects of teaching and learning beyond its own major at most institutions. Like colleagues in writing—but unlike those in physics, philosophy, and French—mathematics faculty had to staff basic skills courses in general education. As a result, both their course designs and pedagogies in such offerings as calculus and statistics must be closely aligned with a range of client disciplines including the sciences, engineering, business, and the social sciences. As a "basic skill," moreover, mathematics is generally assessed already at most institutions in the form of placement examinations, so at least some members of every mathematics department have experience with test construction and use. Where developmental mathematics courses are offered, moreover, they are often evaluated directly because the question of effectiveness is of broad institutional interest—a condition not enjoyed by, say, a course in Chaucer. All these factors meant that at least some members of any institution's mathematics department have at least some familiarity with broader issues of testing, evaluation, and pedagogy.

> The goal for developmental courses seems clear: to prepare students for credit-bearing courses. However, judging by course content, the goal often appears to be remediating what students haven't learned in grades high school. These two goals may be quite different. High schools attempt to prepare students for all possible educational futures. Once a student is in college, however, educational aims may be much better defined. Many students, for example, may not ever need to study calculus. So remediating high school deficiencies may not be necessary or appropriate. The most direct way to assess developmental courses is not to sample student skills in high school mathematics but to investigate student success in subsequent credit-bearing courses.
>
> —Bonnie Gold

Second, mathematics has more explicit connections than most other disciplines with the preparation of elementary and secondary school teachers. Even if mathematics faculty are not explicitly located in mathematics education programs, many at smaller colleges and universities that produce large numbers of teachers are aware of pedagogical and assessment issues through this connection, and this knowledge and inclination can translate quickly to the postsecondary level.

Finally, at least at the undergraduate level, learning outcomes in mathematics are somewhat more easily specified than in many other disciplines. Although I have learned through the SAUM project that mathematicians are as apt to disagree about the nuances of certain aspects of student performance as any other body of faculty—what constitutes "elegance," for instance, or an effective verbal representation of a mathematical concept—they can certainly come to closure faster than their colleagues elsewhere on a substantial portion of what undergraduate students ought to know and be able to do in the discipline. For all these reasons, mathematics was particularly well positioned as a discipline in 2002 to broaden and deepen conversations about assessment through a project like SAUM.

Evaluating SAUM: Some Reflections

Serving as SAUM's external evaluator provided me with a personally unmatched opportunity to explicitly test my own beliefs and assumptions as an assessment practitioner. On the one hand, I have spent almost 25 years advocating for assessment, helping to develop assessment methods and policies, and working with individual campuses to design assessment programs. One cannot do this and remain sane unless one is at some level convinced of assessment's efficacy and benefit. Yet evaluation is an empirical and unforgiving exercise. SAUM's central premise was that it is possible to create a practice-based infrastructure for assessment that departments of mathematics could adapt and adopt for their own purposes, and thus improve teaching and learning. On the larger stage of institutional and public policy, this premise has been the basis for my professional career. The opportunity to "assess assessment" as it was acted out by one important discipline —and to reflect on what I found—was both exciting and sobering.

On a personal note, I also came to strongly value my role as "participant-observer" in the project and the opportunities that it provided me (and I hope to the project's participants) to see beyond customary professional boundaries. For my own part, I was gratified to witness many of the lessons about how to go about assessment that I had been preaching to Provosts and Deans for many years confirmed in microcosm among mathematics faculty at the departmental level. But I also saw (at times to my chagrin) the many differences in perception and failures of communication that can occur when such organizational boundaries are crossed.

As one telling example, at one of the SAUM department-level workshops I encountered a departmental team that reported a particularly frustrating bureaucratized approach to assessment at its institution being undertaken in response to an upcoming accreditation review—an institution that I knew from another source was being cited as a "model" of flexible and creative assessment implementation by the accreditor in question. I like to think that such insights, and they occurred throughout the project, helped keep me humble in the balance of my work in assessment.

At the same time, I like to think that my boundary-spanning role helped participants achieve some of the project's objectives. An instance here, as the previous example suggests, was my considerable ongoing work with accrediting organizations, which allowed me to interpret their motives and methods for SAUM participants, and perhaps set a broader context for their local assessment efforts.

> Although all programs that certify K-12 teachers have some assessment measures in place, these assessments have often been created to satisfy an external requirement rather than to suggest changes in program practice. Program directors typically do not seek data that may suggest that they change their practice. While measures so conceived are not useless, they rarely create productive conversations that lead to enriched student learning.
>
> —Laurie Hopkins

Like many large, multi-faceted projects, SAUM presented many evaluation dilemmas. Certainly, it was perfectly straightforward to conduct formative data-collection efforts intended to guide the future implementation of project activities. For example, we collected participant reactions from the sixteen SAUM workshops conducted at MAA section meetings and used them to focus and improve these sessions. Responses from section meeting participants early in the process stressed the need for concrete examples from other mathematics departments that faculty could take home with them. Participating faculty observed that they often learned as much from interaction with other participants as from the material presented. These lessons were steadily incorporated into sessions at later section meetings (as well as into the design of the SAUM department-level workshops that were beginning to take shape at that time) and participant reactions steadily improved. Similarly, we learned through a follow-up of SAUM department-level workshop participants that a three-meeting format was superior to a two-meeting format and returned to the former in the project's last phase.

But determining SAUM's effectiveness in a more substantive way posed significant challenges. The most important of these was the fact that the bulk of the project's anticipated impact on mathematics faculty and departments would occur (if it did) well after the project was over. (As good an example of this dilemma as any is the fact that the publication in which this essay appears is one of the project's principal products; yet it reaches your hands as a reader only after the conclusion of the formal project evaluation!) Determining SAUM's effect on assessment practice in mathematics departments thus had to be largely a matter of following the experiences of project participants—particularly those mathematics faculty who attended the multi-session department-level workshops—when they returned to their home departments to apply what they learned. We did this primarily through e mail surveys given to participants ten months to a year after the conclusion of their workshop experience. The multi-session format of the department-level workshops also helped the evaluation because at each of the workshop's concluding sessions we were able to explicitly ask participants about their experiences between workshop sessions. What we learned about the experience of assessment at the departmental level is reported in the following section.

We also set the stage for a more formal evaluation of SAUM's impact by conducting an electronic survey of mathematics departments early in the project's initial year. This was intended to provide baseline information about existing department-level assessment practices.

> Accreditation agencies and university administrators generally focus assessment either on the major or on general education. Hence mathematics departments have not felt much pressure to assess mathematics-intensive programs such as courses taken by future engineers, doctors, architects, economists, and other professionals. Thus these "service" courses are ripe for assessment.
>
> —Dick Jardine

A similar survey of departmental assessment practices will be undertaken at the conclusion of the project in the fall of 2005. The baseline survey was administered via MAA departmental liaisons to a sample of 200 mathematics departments stratified by size, institutional type, and location. 112 responses were received after three email reminders sent by the MAA, yielding a response rate of 56%. Questions on the electronic survey were similar to questions that we also posed to 316 individuals who attended SAUM workshop sessions at section meetings, which constituted another source of baseline information.

Justifying the project's potential impact, both sets of baseline data suggested that in 2002 most mathematics departments were at the initial stages of developing a systematic assessment approach. About 40% of department liaisons (and only 20% of participants at section meetings) reported comprehensive efforts in which assessment was done regularly in multiple areas, and another 35% (and 31% of participants at section meetings) reported that assessment was done "in a few areas." About 10% percent of department liaisons (and 21% of participants at section meetings) reported that assessment was "just getting started," and 15% percent (and more than a quarter of participants at section meetings) reported that there was "no systematic effort." Respondents from research universities reported somewhat lower levels of activity than other types of institutions. Differences in responses between department liaisons and the regular mathematics faculty who presumably attend section meetings are notable and reflect the pattern of reporting on institutional assessment activities typical of the late 1980s: in these surveys, administrators routinely reported higher levels of institutional engagement in assessment than was apparent to faculty at their own institutions (El-Khawas, 1987).

Baseline survey results also revealed that the mathematics major is the most popular target for assessment activities, with almost three quarters of responding departments indicating some activity here. About half of the departmental liaisons surveyed indicated that assessment takes place in either general service or remedial courses, and about a third reported that assessment takes place in courses for prospective teachers and in placement and advising. Not surprisingly, community colleges were somewhat more likely to report assessment in remedial and developmental courses, and less likely to report assessment of the major. Masters degree granting universities were more likely to be engaging in assessment of general service courses and courses for prospective teachers. Doctorate-granting research universities were somewhat less likely than others to be undertaking assessment in any of these areas.

> The biggest assessment challenge in college algebra and precalculus is deciding what the goals are. As long as the course is primarily being used to prepare students for calculus, the goals are fairly clear, as is an appropriate assessment: see how well students do in calculus. On the other hand, if the majority of students do not take calculus, the goals of the course are much less clear. In this case, determining why students take the course and how they use it is an essential first step in any assessment process.
>
> —Bonnie Gold

Survey results suggested that mathematics departments are using a wide variety of assessment methods. The most popular method was faculty-designed examinations, which 62% of departments reported using. 53% of departments reported using standardized tests, which is not surprising, but more than 40% of departments reported employing so-called "authentic" approaches like work samples, project presentations (oral and written), or capstone courses. About 40% also reported using surveys of currently-enrolled students and program graduates. Standardized examinations tended to be used slightly more by departments engaging in assessment of remedial and developmental courses, while projects and work samples were somewhat more associated with assessing general service courses.

Finally, the departmental baseline survey asked respondents about their familiarity with *Assessment Practices in Undergraduate Mathematics* (Gold *et al.* 1999), which had then been in print for several years. Some 19% reported that they had consulted or used the volume, while another 35% noted that they were aware of it, but had not used it. The balance of 46% indicated that they were not aware of the volume. As might be expected, awareness and use were somewhat related to how far along a department felt it was with respect to assessment activity. About 61% of respondents from departments reporting comprehensive assessment programs in place said they were at least aware of *Assessment Practices* and about 25% had actively used it. Only about a third of those reporting no systematic plans had even heard of the volume and none had used it. Certainly, these baseline results leave plenty of room for growth and it will be instructive to see if three years of SAUM have helped move the numbers.

Emerging Impacts

Despite the fact that most of the SAUM project's impact will only be apparent after the publication of this report, evaluation results to date suggest some emerging impacts. The majority must be inferred from responses to the follow-up surveys administered to department-level workshop participants about a year after they attended, focused on their continuing efforts to implement assessment projects in their own departments. Many of these results parallel what others have found in the assessment literature about the effective implementation of assessment at the institutional level, and for disciplines beyond mathematics.

> Planning and assessment of courses intended primarily for non-majors should extend beyond the mathematics department. Ensuring that the needs of other majors are met, as well as those of the institution, can do wonders for the reputation of the mathematics department on campus and can lead to support for its other initiatives.
>
> —Bonnie Gold

Colleagueship. Like any change effort in the academy, implementing assessment can be a lonely business because its faculty practitioners are dispersed across many campuses with few local colleagues to turn to for practical advice or support. Indeed, one of the most important early accomplishments of the national assessment movement in higher education was to establish visible and viable networks of institution-level assessment colleagues through such mechanisms as the AAHE Assessment Forum (Ewell, 2002a).

Results of the evaluation to date indicate that SAUM is clearly fulfilling this role within the mathematics community. A first dimension here is simply the fact that SAUM is a network of *mathematicians*, not just "people doing assessment." As one faculty member told us, "history, agriculture, and even physics have differ-

Assessment is a marathon, not a sprint. Formerly, accreditation visits and program reviews were periodic events that prompted frantic last-minute efforts to assemble data in support of vague claims of departmental effectiveness. Now continuous assessment is the goal, the way departments routinely should go about the business of helping students learn mathematics.

—Dick Jardine

ent flavors of assessment from mathematics" and the opportunity to work with other mathematicians on mathematics topics in assessment was critical in grounding effective departmental efforts. Another dimension is simply the reassurance for individual mathematicians who first get involved in local projects that assessment is a going concern. Here it was useful for SAUM participants to learn that many mathematicians are already involved in assessment—more than many realized—and that assessment is not a peripheral activity that only a few mathematics departments are involved in. These points were seen by SAUM participants as particularly important in "selling" assessment to other faculty when they returned to their home departments.

The team basis for participation in SAUM workshops meant automatic colleagueship and mutual support. Simply being away together with colleagues, far from the pressures of everyday campus work was also deemed helpful. At the same time, working with other campuses at the workshop in multiple encounters helped build a feeling among SAUM participants of being part of a larger "movement" that had momentum. This was especially important for faculty who felt, in the words of one, that they had "been thrust into a leadership position on assessment" with little real preparation for this role. Knowing that others were in the same position and sharing approaches about what to do about it was seen as especially important.

The same was true of learning about more specific assessment approaches where, as expected, SAUM departments borrowed liberally from one another. But by far the most important impact of having colleagues was the stimulus they provided to keep participating departments moving. The need to present departmental progress periodically and publicly was important to this dynamic: teams at the workshops knew that they were going to have to report to their peers, so worked hard to have something to say. As one representative noted, "if we had run out of time and didn't accomplish what we intended, it probably wouldn't have had any consequences on campus—we were already doing more than most departments—but because we had to have presentations ready at different workshops we were pushed to follow through on plans and to discuss and revise our activities." This "peer stimulation" effect was a particularly important dynamic in SAUM, and parallels similar lessons learned about colleagueship in other assessment-related change projects (e.g., Schapiro and Levine, 1999).

The final stage in an assessment program is the feedback loop. What do the results say about whether students are meeting the goals the faculty has set, and whether the departmental program is designed in such a way that the students can meet those goals? In other words, if students are falling short, is it the students who are underperforming or is it the program that is deficient? In either case, the faculty needs to review the program to see what improvements can be made so that students are successful in developing the desired competencies.

—William Marion

On a more sobering note, however, early evaluation results also suggest the difficulty of maintaining colleagueship absent the explicit framework of a project or a visible network to support it. Few departmental representatives reported contacting other participants on their own, largely due to pressures of time. Again confirming lessons of the assessment movement more generally, an infrastructure for sustaining assessment in mathematics must be actively *built*; it will not just happen as a result of peoples' good experiences. *Learning By Doing*. Another lesson of the assessment movement nationally was the importance of early hands-on experience and practice. Evaluation results to date suggest that SAUM is strongly replicating this finding within mathematics departments. Rather than looking for the best "model program" and planning implementation down to the last detail, SAUM departments, like their colleagues in many disciplines, learned quickly that time invested in even a messy first effort trumped similar investments in "perfecting" design. As one participant told us, "the most important lesson that I learned was to just get started doing something." Another said, "begin with a manageable project, but begin." Small projects can not only illustrate the assessment process in manageable ways with only limited investments of resources but can also quickly provide tangible accomplishments to show doubting colleagues. The importance of this insight was reinforced by the fact that most participants also discovered that assessment was a good deal more time-consuming than they had first imagined, even for relatively simple things.

At the same time, participating departments learned the importance of finding their own way *in* their own way, and that local variations in approach are both legitimate and effective. Like their colleagues elsewhere in assessment, they also learned tactical lessons about implementation that could only be learned by doing. As one department reported, "for us, designing an assessment program means finding a balance between getting good information ... and not increasing faculty workload too much." Additional comments stressed the importance of knowing that "one size does not fit all" and that good assessment should be related to local circumstances.

Finally, participants encountered aspects of local departmental culture that could not be addressed through formulaic methods. One of them summarized this condition nicely: "there are rules at my institution about how we have to do assessment even though those rules are unwritten, unarticulated (except when violated), and specific to my institution and the larger community. I used to think that these rules were to be found somewhere in the literature ... now I know that I'm dealing with the unknown and with rules that are likely being made up as we go. This makes me much more confident in my own ideas instead of backing down when I am told that something is 'not allowed.'"

SAUM Workshop: does anybody have an idea?

Growing Maturity. As their projects evolved, most participating departments reported a growing maturity with assessment. Several departments doing program-level assessment, for example, had replicated their assessment models in another related department or program (e.g., computer science), or had been working with other departments at the institution to help them develop an assessment approach. Others implemented or regularized activities that they had planned or experimented with at the workshop. Most indicated that they had expanded their departmental assessment efforts to become more systematic and comprehensive—adding new assessment techniques and applying them to more courses or involving more faculty. As one participating department reported, "We believe one of our greatest accomplishments is to have engaged a significant proportion of the department (more than half the faculty) in assessment in one way or another."

Growing maturity is also apparent in organizational and motivational dimensions. With regard to the former, several departments reported that they had discovered the importance of having a departmental advocate or champion for assessment who could set timelines, enforce deadlines, and provide visibility. A few also reported "regularizing" assessment activities—in one case allowing the original project leader to hand off assessment activities to a newly interested faculty member to coordinate or lead. As one departmental representative put it, participating "got us off to a great start and developed a sense of confidence that we are in a better posture with assessment than other departments on our campus."

Motivational shifts were more subtle, but reflected a shift toward internal instead of external reasons for engaging in assessment. Mirroring experience in other fields, many mathematicians first heard about assessment through accreditation or their administration's desire to "create a program." But as their participation in SAUM progressed, many also reported new attitudes toward assessment. As one faculty member put it, "Earlier [activities] were about responding to outside pressure…[later activities] were about doing this for ourselves." Another noted, "Most people [at my institution] are not as advanced in assessment as we are in the mathematics department. ... The task still seems to most people like a necessary activity conducted for external reasons, rather than an activity that has intrinsic value to improve their own work." This shift requires time to accomplish and findings from other fields emphasizes the fact that outside pressures or occasions are important to start things moving on assessment at the institutional level (Ewell, 2002b). But SAUM participants began to recognize also that sustaining assessment requires the kind of internal motivation that can only be developed over time and through collective action.

Changing Departmental Culture. Twenty years after the emergence of assessment as a recognizable phenomenon in higher education, it has yet to become a "culture of use" among faculty in disciplines that lack professional accreditation. Many reasons for this have been advanced, ranging from alien language to lack of institutional incentives for engagement, but by far the most prominent is the imposition of assessment requirements by external authorities (Ewell, 2002a). Consistent with national experience in other disciplines, SAUM workshop participants thus returned to their own departments determined to make a difference, but they faced an uphill battle to change their colleagues' attitudes about assessment and, in the longer term, to begin to transform their department's culture.

A first milestone here was the fact that participation in SAUM itself helped legitimize the work of developing assessment. Being part of a recognized, NSF-funded project was important in convincing others that the work was important. So was the clear commitment of workshop participants to working on their projects. As one faculty member told us, "Because [the participants] were genuinely interested, ... that interest and enthusiasm has been acknowledged by others." Several also mentioned the value of knowing the "justifications for assessment" in communicating with fellow faculty members.

But SAUM participants also tended to end up being the "assessment people" in their departments—accorded legitimacy for their activities to be sure, but not yet joined by significant numbers of colleagues. As one wryly stated, "it has probably made more work for me as when I share an idea of something that we can do, I usually get put in charge of doing it." Another doubted that he and his SAUM teammate had gained much stature in the department because of their participation, "but I guess at least more people recognize what we have done."

As national experience suggests, moreover, wider impacts on departmental culture with respect to assessment require time to develop—more than the three years of engagement most SAUM participants have to date enjoyed. Most indicated that their colleagues were in general more informed about assessment as a result of SAUM and were therefore more willing to agree that it might be beneficial for their departments or institutions. So despite little groundswell of enthusiasm, most did report slow progress in changing departmental attitudes. One participant captured the typical condition succinctly when he reported that his colleagues "remain largely indifferent to assessment…they are in favor of improving programs as long as it doesn't bother them." Another described this condition as follows: "I think there is still a degree of skepticism about all of this, but at least we don't run into outright hostility or claims that this is all a great waste of time and effort." Echoing these comments, a third reported that "the department has definitely become more open to the idea of assessment ... for one thing, they have finally realized that it is not going away ... for another, if there is someone willing to do the work, they will cooperate." These are no small achievements. But the overall pattern of impact to this point remains one of increased awareness and momentum for assessment among SAUM departments with only a few early signs of a changed departmental culture.

> Effective placement can be crucial to student success. Good placement processes generally involve multiple components including results of a placement test, high school rank, grade point average, last mathematics course taken, SAT or ACT scores, and student self-descriptions of how good they are at mathematics. Examining how well each factor and the overall system predicts success and adjusting the formula in response to this analysis is an important part of the assessment of these introductory courses.
>
> —Bonnie Gold

"Assessing assessment" through the SAUM evaluation remains an ongoing activity. Like assessment itself in many ways, the task will never be finished. But it is safe to conclude at this point that mathematics has built a resource through SAUM that if maintained, will be of lasting value. On a personal note, I have learned much from my colleagues in mathematics and have been grateful for the opportunity to work with them on a sustained basis. And from a national perspective, I can say without reservation that they are making a difference.

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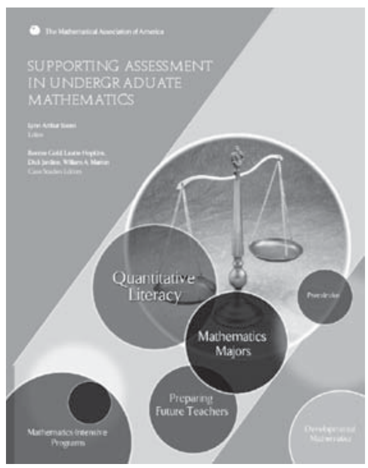

A complimentary copy of the report *Supporting Assessment in Undergraduate Mathematics* is available to the first 1000 departments submitting requests through the project website http://www.maa.org/saum.