# MAA FOCUS


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MAA
MATHEMATICAL ASSOCIATION OF AMERICA

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# From the Editor

**In today's politically charged environment,** we should all be conscious of how our actions represent us. As an organization, MAA is committed to diversity and inclusiveness. Our Welcoming Environment Policy states, "The MAA encourages the free expression and exchange of ideas in an atmosphere of mutual respect and collegiality. The MAA strives to foster a welcoming environment for all, as a professional society supporting open discussion of mathematics and mathematics education." STEM communities have not always been good about this, but we hope we are moving in the right direction—and will continue to do so.

MAA welcomed me, a woman, when I was a graduate student and attended my first section meeting. I was lucky because my graduate program was half women, and it did a great job offering a comfortable, challenging, and cooperative environment for us. However, when I went to research conferences, this was not always the case. Frequently I was one of a few women present, and the speakers were almost entirely men. Whether intentional or not, this changed the environment, and I often felt more out of place at these conferences.

When I went to that first section meeting, and then again at national meetings, MAA members encouraged me to engage, to present, to welcome students of my own. We have always been a strong group of people committed to mathematics and mathematics education. In today's society, where extreme rhetoric makes many groups feel unsafe or unwelcome, the supportive nature of the MAA is more important than ever before. We are committed to building a community that welcomes all, without regard to gender, race, ethnicity, or sexual orientation. Additionally, both MAA and AMS ask all the major vendors at the Joint Mathematics Meetings to commit to respecting our Welcoming Environment Policy.

So I ask, as you prepare for your trip to the Joint Mathematics Meetings or to your section meetings in the spring: please look for the new people, and the people who are underrepresented, and help them feel welcome. Show them that they have a place and a voice in our association and that we are glad to have them as part of our community.

Jacqueline Jensen-Vallin

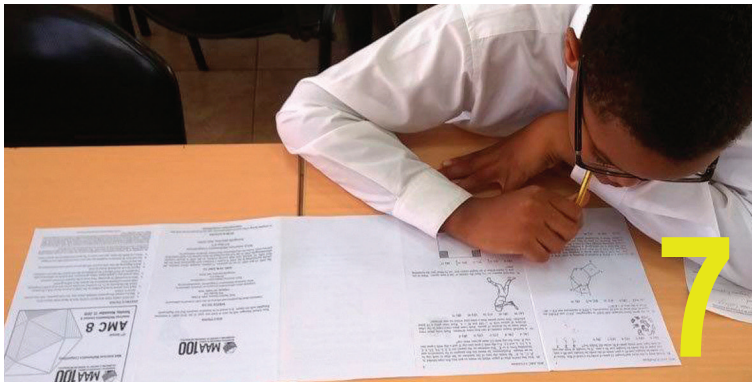
**ON THE COVER**

*UnKnot III conference, held before MAA MathFest 2016. Photo by Patrick Smith/Denison*

# MAA FOCUS

Mathematical Association of America

Vol. 36, No. 6 | DECEMBER 2016 /JANUARY 2017


## *in this* ISSUE



## *news*



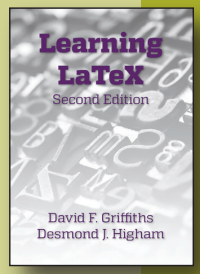
## *departments*

# Applied Math Titles *from* siam®

## A new edition of SIAM's must-have handbook

### Learning LaTeX, *Second Edition*

David F. Griffiths and Desmond J. Higham




Here is a short, well-written book that covers the material essential for learning LaTeX. It includes incisive examples that teach LaTeX in a powerful yet abbreviated fashion. This is the handbook to have if you don't want to wade through extraneous material. This manual includes the following crucial features: numerous examples of widely used mathematical expressions; complete documents illustrating the creation of articles, reports, presentations, and posters; troubleshooting tips to help you pinpoint an error; details of how to set up an index and a bibliography; and information about online LaTeX resources.

*2016 • Approx. x + 103 pages • Softcover • 978-1-611974-41-6 • List Price $29.00 • SIAM Members $20.30 • OT148*

*"Hurrah, my favorite beginner's guide to LaTeX has been updated and improved and is as concise and fresh, and funny, as ever. It has been near my computer since its first release. [The authors] will get you and your students up to speed with great examples and handy templates."*

— Margot Gerritsen, Stanford University

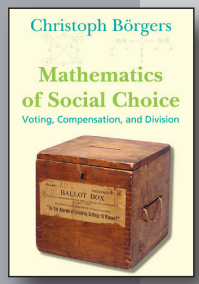
*"A quick-start guide for LaTeX beginners that will have readers off and TeX-ing in no time. Highly recommended for newbies, though veterans will also appreciate it as an essential reference. Highly recommended as part of every professor's lending library and every student's essentials."*

— Tamara G. Kolda, Sandia National Labs

## Cast your vote for this great Election Year title

### Mathematics of Social Choice: *Voting, Compensation, and Division*

Christoph Börgers




How do you select a winner from a field of candidates? How do you rank a field of candidates? How do you share a divisible resource like a cake, or an indivisible one like a pet or a house? These are the questions addressed in this fun and accessible book that takes an entertaining look at the choices made by groups of people with different preferences, needs, and interests.

Divided into three parts, the text first examines voting methods for selecting or ranking candidates. A brief second part addresses compensation problems wherein an indivisible item must be assigned to one of several people who are equally entitled to ownership of the item, with monetary compensation paid to the others. The third part discusses the problem of sharing a divisible resource among several people.

*2009 • xii + 245 pages • Softcover • 978-0-898716-95-5 • List Price $39.00 • SIAM Members $27.30 • OT119*

*This book is primarily addressed to readers without a high-level mathematical background, such as college students majoring in subjects other than mathematics and advanced high school students. However, some material appropriate for more sophisticated readers is also included and makes the text appealing to undergraduate mathematics majors interested in learning about applications of mathematics in the social sciences. The book can also serve as an easy introduction to topics such as the Gibbard–Satterthwaite theorem, Arrow's theorem, and fair division for readers with more mathematical background.*

## TO ORDER, *shop online at bookstore.siam.org*

**Use your credit card (AMEX, MasterCard, and VISA) by phone: +1-215-382-9800 worldwide or fax: +1-215-386-7999. Or send check or money order in US dollars to: SIAM, Dept. BKMF16, 3600 Market Street, 6th Floor, Philadelphia, PA 19104-2688 USA. Members and customers outside North America can also order through SIAM's distributor, Cambridge University Press, at *www.cambridge.org/siam*.**

*All prices are in US dollars.*

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10/16


NASA

### *Astronomical Connection: Pluto and the Putnam*

- In November, Pluto was in the news as scientists said that there may be a subsurface ocean beneath its surface.
- On the first Saturday of each December, about 4,000 undergraduates sit for the William Lowell Putnam Mathematical Competition.

What's the connection? The 12-problem Putnam exam was named by Elizabeth Lowell Putnam in honor of her husband. She was the sister of Percival Lowell, an astronomer. Pluto was discovered at the Lowell Observatory, which Percival founded. The Putnam and Lowell families were related by blood as well as marriage. To read Heather Lewis's full article on this historical note on the Putnams, go to maa.org/maa-focus-supplements.

## Section Elections

The following 10 sections will have elections from February 2 through March 9.

● Allegheny Mountain ● Golden ● Indiana ● Kentucky ● Metropolitan New York ● Nebraska–SE South Dakota ● North Central ● Oklahoma-Arkansas ● Rocky Mountain ● Wisconsin

## Toward Active Learning

In July, the Conference Board of the Mathematical Science released a statement calling for a community-wide effort to implement active learning experiences, which was signed by MAA president Francis Su. The MAA is working on an instructional practices guide that will serve as a practical handbook and policy document while undertaking this effort.

Related to these themes, there is a special issue of *PRIMUS* on teaching inquiry, which presents guidance on how to organize mathematics classrooms around student-centered inquiry; the issue will be freely accessible temporarily in January 2017 (*tandfonline.com/toc/upri20/current*). The special issue contains 19 accessible papers and two editorials by mathematicians and education researchers that illuminate the nature of inquiry, share existence-proofs for implementing inquiry in a variety of contexts, and connect design for inquiry with the goal of giving more students access to mathematics and its benefits.

## Homegrown Japanese Mathematics

In the November *Math Horizons,* David Clark writes about taking students to Japan to see mathematical art on tablets hung in shrines and temples (http://bit.ly/japanmath). *Wasan* is a homegrown mathematics developed while the country was closed to foreigners. It's an art form largely unknown to Western scholars.

Clark, an associate professor of mathematics at Randolph-Macon College, is planning a conference on the subject, which combines history, art, math, and Japanese culture. The conference is scheduled for April 28–29, 2017, in Virginia. He can be reached at DavidClark@rmc.edu.

DAVID CLARK

## The UnKnot Conference

PATRICK SMITH/DENISON

—Colin Adams and Lew Ludwig

**UnKnot III was held** July 31–August 2. No, it was not an entire conference devoted to the unknot, which is the trivially knotted circle. Rather, it was a conference devoted to research by undergraduates in knot theory. The conference brought together several categories:

- Faculty who advise students on research in knot theory, and those who would like to advise such students;
- Students who have completed knot theory research and those who would like to do research in knot theory; and
- Experts from the field.

Although the conference is geared toward undergraduates, it has the same rigor as most research conferences, with three days of talks on many different aspects of the field of knot theory. Within the span of these three days, there were 14 invited plenary talks and 27 contributed talks, given by both faculty and students.

Those invited to speak at the conference were selected based on their reputations as knot theory experts known for their skill at delivering expository talks at the right level. There was also a workshop presented by Laura Taalman about 3D printing of various knots that included the opportunity to print.

The conference was held at Denison University, Granville, Ohio, as were UnKnot I in 2009 and UnKnot II in 2012. For Unknot III, we intentionally scheduled the conference to fall right before MAA MathFest, taking place in Columbus, only a half-hour away. In addition to ferrying people to and from the airport, we provided transportation to MAA's conference at the end of UnKnot III.

To continue our outreach, we organized an invited paper session on knot theory at MAA MathFest, bringing in our experts from UnKnot, for the benefit of both MathFest and UnKnot attendees.

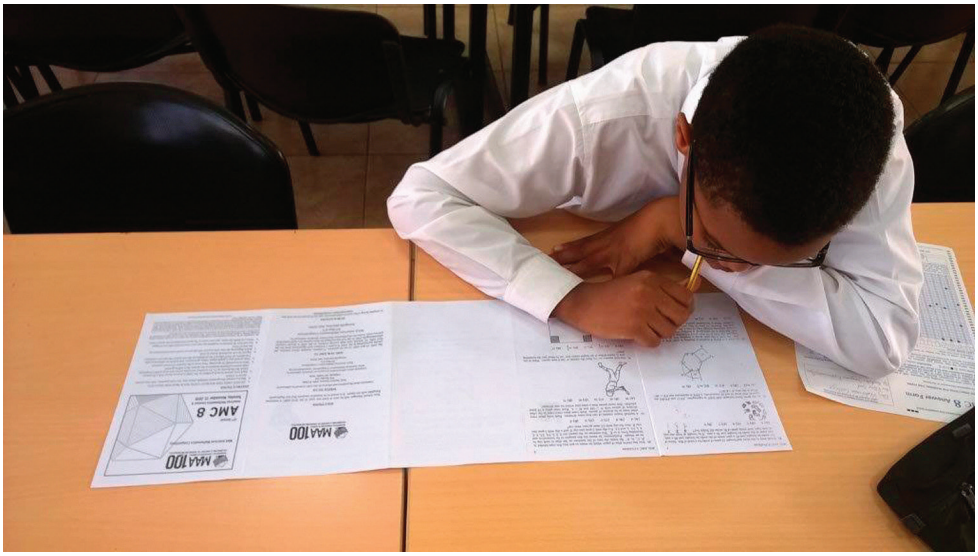
The conference was funded with support of the National Science Foundation (NSF grant 1561524), which covered housing costs for all participants and almost all transportation costs for students and faculty. The Provost Office at Denison University generously provided breakfast as well as coffee breaks. We charged a registration fee of $100 to faculty only, which covered snacks and two dinners for all participants.

### *Let's Do More*

The idea of a conference with a specific theme, but with undergraduate research and research opportunities in that area as the focus, seems to be a great model. Faculty who work with undergraduates in other areas of math should consider this option. The impact on both students and educators is substantial. For students interested in a subject, attending a conference specifically focused on that subject gives them the opportunity to interact with others who have the same enthusiasm and interests as themselves. It can be a cathartic experience. Seven years in, we are now seeing individuals who participated as students in previous versions of the UnKnot conference leading their own research groups in knot theory. These new students will go on to become the next generation of researchers in the field.

*Colin Adams is the Thomas T. Read Professor of Mathematics at Williams College. Lew Ludwig, a professor of mathematics at Denison University, holds the Nancy Eshelman Brickman Endowed Chair.*

## A Facelift for International Participation in the MAA Mathematics Competitions



**The roots** of the American Mathematics Competition (AMC) go back to 1950 when the first "Mathematical Contest," sponsored by the New York Metropolitan Section of the MAA, took place. That contest was given in 200 schools to 6,000 students in the New York City area. Today, the competition has grown to annual participation of more than 350,000 students in over 6,000 schools from almost 50 countries.

In recent years, the growing level of participation from outside the United States has put a strain on the MAA systems, which were designed for a domestic, school-based program. In response, the 2016-17 contest cycle features a new model for international participation, based on licensing the exams to group leaders who can run the contest autonomously within their geographic area.

Other than appropriate attention paid to exam security and exam timing, the international partners will simply conduct the exam in a manner appropriate to the local situation and send to MAA the student scores for integration with the global contest database.

These changes greatly improve the the MAA's ability to conduct the exam outside of the United States cost-effectively and reliably, and this ability, in turn, will lead to greater capacity to distribute the AMC competitions even more broadly around the world.

For the 2016-17 contest cycle, the MAA has already partnered with 13 group leaders who will be delivering the exams in 17 countries. We are particularly pleased that the largest groups have all been able to adapt nimbly to the new format.

Altogether, the 17 participating countries represent regions that account for 95 percent of the total international registration from the previous year. The top six countries with their participation numbers from the 2015-16 contest cycle are shown in the chart at the bottom of this page.

The total participation in 2015-16 outside of the United States and Canada was 42,600 for AMC 10/12 and 6,600 for AMC 8.

A complete list of partners can be found at maa.org/math-competitions/international-registrations. We invite MAA members with international contacts who may want to be involved with AMC to share that information with us (amchq@maa.org).

*—Doug Ensley*
*MAA Deputy Executive Director and Interim Director of Competitions*

*Above: Ifeanyi Oguamanam (Grade 6) taking the AMC 8 in Nigeria (Photo by Daniel Akintoye)*

### International Participation in MAA's AMC 8 and 10/12 Competitions

| 2015-16 | China | Hong Kong | Nigeria | Singapore* | South Korea | Taiwan | TOTAL |
|---|---|---|---|---|---|---|---|
| AMC 8 | 1,100 | 1,000 | 0 | 300 | 700 | 200 | 3,300 |
| AMC 10/12 | 12,400 | 400 | 2,600 | 3,300 | 1,400 | 16,000 | 36,100 |
| **TOTAL** | 13,500 | 1,400 | 2,600 | 3,600 | 2,100 | 16,200 | 39,400 |

*Our Singapore group leader also manages the competition in Indonesia and Malaysia.

## MAA Seeks a Publications Partner

—Jennifer Quinn

**Academic publishers,** including the MAA, are facing new challenges in today's high-tech global marketplace. For more than one hundred years, MAA has published high-quality mathematical exposition—both in journals and in books. The quality of MAA products is stellar, but our business model needs to adjust to the new reality of the publishing profession.

Industrywide, journal publishers have noted a shift in revenue from individual print subscriptions to institutional site licenses. Meeting this change requires adjustments in marketing and production. Additionally, there have been sweeping changes in technology and in the technological infrastructure used to communicate science and mathematics. Adapting to these changes requires expertise and technologies, as well as infrastructure in global sales and marketing, at a scale that is not possible for MAA acting independently.

### *The Right Time*

Given this situation, MAA has determined that it is the right time to solicit proposals for publishing partnerships, one for journals and one for books, so that the association can focus its energies and resources on continuing to develop preeminent expository content.

The MAA journals represent an increasingly valuable resource and a market opportunity for the right publisher. Although the number of research articles published each year across the mathematics disciplines has been increasing (MathSciNet indexed 100,414 in 2015, up from 87,736 in 2010), there has not been an analogous rise in the publication of expository literature or an increase in expository journals—meaning that the MAA journals are in the leading position in what is arguably an underserved market.

MAA volunteer professionals and staff should be proud of their role in developing and maintaining this remarkable publication program. Finding the right publication partner will benefit the program by improving production processes, raising revenues, and extending the impact of association journals.

A request for partnership proposals with MAA journals, created in consultation with STM Advisers, was issued September 30. Proposals will be carefully analyzed with respect to

- the financial structure of the proposed partnership;
- experience and qualifications in production, marketing, and digital technologies; and
- the preparation of a market strategy beneficial to MAA and aligned with the strategic direction of the association.

The intent is to conclude contract negotiations with the selected publisher by mid-March 2017 and have issues produced by the new publisher beginning January 1, 2018.


TASHATUVANGO/123RF

### *For Readers*

How will this transition affect readers of MAA journals? By partnering with a larger publisher, MAA expects to gain efficiency and access to a full range of publications professionals

to ensure consistent production timelines. It will be easier to read the journals online, whether that's on desktop computers or mobile devices. And although the vendor handling institutional access may change, an outreach campaign will work to smooth the transition for existing library subscriptions, as well as expand MAA's subscription base.

### *For Authors and Reviewers*

How will this transition affect authors and reviewers of MAA journal articles? The *American Mathematical Monthly, Mathematics Magazine,* and the *College Mathematics Journal* represent the hallmarks of expository writing in mathematics and a foundation of undergraduate and graduate mathematics education.

Editors of the journals will continue to control content in collaboration with their appointed boards and expert referees. Publication standards will not change. The mechanics of submitting a manuscript or referee report might alter as MAA and our new partner align our processes, especially if the user experiences can be improved.

### *Math Horizons*

What about *Math Horizons*? The publication parameters for *Math Horizons,* a mathematics magazine, are quite different from those of the three academic journals. A publication plan for *Math Horizons* was an optional component in the requested proposals. MAA is committed to continuing publication of *Math Horizons.* In fact, searches for the next editor of *Math Horizons*—as well as of the *College Mathematics Journal*—is under way. See the call for applications and nominations below.

*MAA FOCUS,* the association's newsmagazine, was not included in the request for proposals and will not be affected by the change.

The books program is undergoing a similar proposal process to find a publishing partner. A request for proposals is under development.

*Jennifer Quinn (University of Washington Tacoma) chairs the Council on Publication and Communication.*

**_CMJ_: Search Is on for a New Editor**

The Mathematical Association of America seeks to identify candidates to succeed Brian Hopkins as editor of the *College Mathematics Journal* (*CMJ*) when his term concludes in December 2018. *CMJ* is an expository journal of mathematics accessible at the early undergraduate level, with cover dates of January, March, May, September, and November. The position of *CMJ* editor typically requires a time commitment of about three days per week. Duties extend throughout the year, with a somewhat quieter period in March. The ideal candidate will bring excellence and experience in exposition, organization, and editing. The editor is expected to lead an editorial board, effectively manage the flow of manuscript decisions, and promote the integrity and excellence *CMJ* is known for.

Working in cooperation with MAA's Journals Managing Editor and Assistant Managing Editor, the *CMJ* editor will create timely journal issues of the highest quality. Other support, largely in the form of course release time, is available.

Applicants should submit a curriculum vitae, the names of three references, and a statement of experience and interest containing a vision of and ideas about the journal. Nominations are welcome. Review of applicants will begin March 15, 2017, with appointment as editor-elect to commence on January 1, 2018. The five-year editorial term runs January 1, 2019, to December 31, 2023. Send inquiries, nominations, and applications to hr@maa.org.

**_Math Horizons_: New Editor Sought**

The Mathematical Association of America is seeking a new editor for *Math Horizons* to succeed David Richeson when his term concludes in December 2018. *Math Horizons* is the MAA magazine for mathematics enthusiasts. The ideal candidate will have a wide-ranging interest in mathematics, as well as its culture, history, institutions, and people. She or he will also need to be an excellent expositor, a painstaking editor, and a careful manager.

*Math Horizons* is published with cover dates of February, April, September, and November. The position typically requires a time commitment equivalent to about two days per week. Duties extend throughout the year. The editor works in collaboration with an editorial board and with MAA's magazines managing editor. Other support, largely in the form of course release time, is available.

An application consists of a curriculum vitae, a letter of interest outlining a vision for *Math Horizons,* and the names and contact information of three references willing and able to answer questions from the Search Committee about the applicant's writing, editing, and organizational skills. Joint applications from prospective editorial teams are welcome. Review of applications will begin on March 15, 2017. The term as editor-elect begins January 1, 2018. The five-year editorial term runs January 1, 2019, through December 31, 2023. Send inquiries and applications to hr@maa.org.

Dear Liaisons,

At its August meeting in Columbus, the MAA Board of Governors voted to discontinue the MAA/Department Liaisons program. This was not an easy decision. For the past two decades, liaisons have shared information from the MAA with their colleagues and helped promote the association on their respective campuses. But modes of communication are much different today than they were in the 1990s. When the program began, liaisons received mailings with posters to display and brochures to distribute on campus, but electronic communication is now the norm, and the Washington office sends Math Alerts and targeted emails directly to members.

When the results of the October 2014 survey (distributed to liaisons and section officers) and the feedback from liaisons meeting at the 2015 JMM were analyzed, it was clear that liaisons play an important role in many sections. So while the current liaisons program is ending, a number of sections will be maintaining their own liaisons networks and using liaisons to support section activities.

Whether you have been a liaison for only a short time or you have been a liaison since the program's inception, your efforts on behalf of the MAA are greatly appreciated. Please continue to share your time and talents to support the work of the association and your section. If you are interested in serving as a liaison at the section level, please reach out to your section's governor or liaison coordinator.

MAA/Department Liaisons provided important service to the association. Thank you for being a part of the liaison network.

Francis E. Su

Francis Su, MAA President

## Service Award Nominations Sought

**The Yueh-Gin Gung and Dr. Charles Y. Hu Award** for Distinguished Service to Mathematics is the most prestigious award for service offered by the MAA. It recognizes service to mathematics that has been widely recognized as extraordinarily successful on a national scale. The service may comprise one or more activities, and the period of service may have been short or long.

The nature of the service has varied widely among past awardees and includes mathematical writing and editing, advancing diversity, leading professional organizations, and educating those who will teach mathematics.

Please send the names of those who should be considered for the 2017 Award to the chair of the Gung and Hu Award Committee, Doug Ensley (densley@maa.org) by December 15. Include a short discussion of the reasons behind your nomination, highlighting the most important aspects of the person's contributions and impact. Lengthy documentation and letters of recommendation are not necessary. More information about the award, including a list of past winners, can be found at http://bit.ly/gunghu.

# Silver and Gold Anniversaries as Members

Every year, we celebrate members who reach 25 years and 50 years of membership in the MAA. As the world's largest community of mathematicians, mathematics students, and enthusiasts, MAA appreciates all its members.

## 25 Years

Dora Cardenas Ahmadi
Alexander A. Ambrioso
Fredric D. Ancel
Pau Atela
Byron J. Bang
William S. Barfield
Alan Bawden
Philip F. Beaver
Diego M. Benardete
Christopher P. Bendel
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John W. Wood
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Craig L. Wright
Connie H. Yarema
Osman Yurekli
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## 50 Years

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Kenneth F. Andersen
Joel H. Anderson
John W. Andrews
Thomas E. Armstrong
Richard M. Aron
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Leo Barsotti
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Ian M. Ferris
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David Fowler
Murray Gerstenhaber
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Sandy Grabiner
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MATHEMATICAL ASSOCIATION OF AMERICA

We are embarking on the Mathematical Association of America's second century of advancing mathematics! As we approach the end of 2016, we ask that you consider all that math has done to shape your life and the world around you. Will you support the MAA's innovative programs by making a contribution today?

In our first hundred years, our worldwide community of mathematicians, students, and enthusiasts has transformed the teaching and practice of mathematics, and we could not have done this without your generosity and support. The strength of the MAA community allows us to do together what we cannot do alone.

Our goal for the next hundred years is to promote the ever-expanding role of mathematics in our increasingly digital world. We are committed to building a generation of innovative thinkers capable of taking on the challenges of the 21st century. As our evolving global economy demands new sets of quantitative and analytical skills in the workforce, we seek to adapt our programs and expand our network, reaching more people than ever before.

This past year, the MAA's American Mathematics Competitions program cultivated and trained the members of the U.S. International Mathematical Olympiad team that took first place in Hong Kong! We are also proud to share that five MAA articles were featured in Princeton University's most recent edition of *Best Writing in Mathematics.* The MAA elevated mathematics in the mainstream media, perhaps most notably with our story "The Network of Thrones," which was published in a variety of major media outlets including the *Huffington Post*, *Forbes*, and NPR.

As mathematics becomes more visible, we have a unique opportunity to build on our history, our mission, and the strength of our discipline. We want you to be a part of this important moment in our history.

Help us deepen our impact by making a gift today that builds the MAA for future generations. With your tax-deductible contribution, you can become an integral part of our ground-breaking launch into the second century.

With sincere thanks,

Michael Pearson
Executive Director

Francis Su
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# A Delicate Balance

# Quantitative Literacy and Equity

*Kira Hamman and David Kung*

There can be no question that the accelerating movement toward quantitative literacy in higher education is inspiring. The past 15 years, dating from the 2001 publication of Lynn Steen's *Mathematics and Democracy: A Case for Quantitative Literacy,* have been exciting, challenging, and deeply rewarding. Where we once pushed virtually all students into terminal algebra and calculus courses they hated only to watch them fail in staggering numbers—sometimes blocking them from college graduation entirely—we now offer a range of courses commensurate with the beauty, utility, and scope of mathematics. This is an impressive achievement, and we can be justifiably proud of it.

Yet we are alarmed that this vital and popular movement appears to be on a collision course with another, equally critical movement in mathematics education: the civil rights–inspired push to make sure students from all backgrounds, including those at poor, mostly minority schools, have access to high-quality mathematics instruction. This movement has its roots in the Algebra Project, founded by civil rights veteran Robert Moses nearly 35 years ago in response to the fact that black students were underrepresented in middle school algebra classes. Moses believed that middle school algebra acted as a gatekeeper course for the college track in high school, and at the time many predominantly black middle schools did not even offer it. The battle cry of the Algebra Project was, and still is, "Algebra for all!"

These apparently conflicting movements spring from the same fundamental belief: that mathematics literacy is critical for full citizenship and that "people who don't have access to it are like the people who couldn't read and write in the industrial age" (Moses, 2001). In our experience, the vast majority of college mathematics faculty share this belief, and they despair of a climate in which the need for mathematics education is considered open for debate. The popularity of Andrew Hacker's recent book-length screed expanding on his 2012 viral rant against teaching mathematics at all is an indication of just how poorly we have communicated the indispensability of mathematics to nonmathematicians.

What Hacker really objects to is not mathematics, which he deeply misunderstands, but the traditional single-minded, race-to-calculus curriculum. The type of mathematics education Hacker envisions actually requires great facility with algebraic concepts. What it does not require is that those concepts be taught as an arbitrary set of rules and procedures devoid of context and meaning.

**We are suggesting neither a return to requiring pure algebra courses of all students nor the banishing of algebra.**

We are suggesting neither a return to requiring pure algebra courses of all students nor the banishing of algebra from the precollege curriculum entirely. Rather, we wish to point out that there are still serious equity issues in mathematics education and that the trend toward parallel STEM and non-STEM mathematics tracks will, in the current environment, exacerbate economic segregation.

Given U.S. demographics and college entrance requirements, such tracks will disproportionately exclude communities of color from higher education and STEM careers. The quantitative literacy movement in higher education must engage with K-12 educators to ensure that *all* students have access to meaningful, challenging, and integrated mathematics instruction.

We call on the mathematics community to lend vocal

support to integrated algebra and quantitative literacy instruction in the K-12 curriculum and to push back against antimathematics rhetoric. In particular, we must publicly defend the sense-making goals of the Common Core State Standards for Mathematics, while simultaneously pushing back against the associated testing regimen.

We must explain the role Common Core can play in advancing the goal of educational equity by ensuring that all students have access to high-quality, meaningful mathematics education. When faced with attacks like Hacker's, we must respond not only with the passionate defenses of Keith Devlin (http://bit.ly/devlin-myth) and James Tanton (http://bit.ly/tanes-say), but push the conversation to address the overlooked equity issues.

We must find a way to balance the need for equity and access for all students with the goal of providing meaningful, useful experiences for students not heading toward STEM careers. The so-called achievement gap is in large part really an access gap. There is a very real risk that, for all its good intentions, the movement away from teaching all students algebra will widen that gap. How to integrate the quantitative literacy movement in higher education with the need for equal access in the K-12 system is an urgent question. In our enthusiasm to reform the undergraduate curriculum, we must not lose sight of the fact that quantitative literacy is inextricably linked to social justice and to the health of our democracy.


*Mathematicians should advance the goal of educational equity by ensuring that all students have access to high-quality, meaningful mathematics education. Graphic by Jack Hagley (www.jackhagley.com).*

*Kira Hamman is a professor at Pennsylvania State University–Mont Alto. Dave Kung is professor at St. Mary's College of Maryland and director of MAA's Project NExT.*


# The Adventure and Importance of Teaching Quantitative Literacy

*Stuart Boersma and Caren Diefenderfer*

*Curriculum Renewal Across the First Two Years (CRAFTY) is a subcommittee of the MAA's Committee on the Undergraduate Program in Mathematics (CUPM). This article is the fifth in a series about general recommendations to renew mathematics course work and instruction.*

As more colleges and universities offer quantitative literacy (QL) courses, faculty members have come to realize that these courses provide an amazing teaching opportunity. Teaching QL courses can be simultaneously challenging and rewarding. Challenging because teaching a QL course forces us to confront our beliefs about what constitutes college-level mathematics. Rewarding because we see students becoming much more familiar with the quantitative world around them. Many faculty teaching QL choose to experiment with innovative pedagogies and step out of their comfort zone with course content, making these courses both liberating and demanding.

Interestingly, there is no universally accepted definition of "quantitative literacy" or

"quantitative reasoning." There is no traditional syllabus etched in stone and passed down from teacher to teacher. Quantitative literacy has been described as a "habit of mind" or a "predisposition" to carefully critique and analyze quantitative information. Helping to create quantitatively literate graduates should be a goal for all educators as "quantitative literacy empowers people by giving them tools to think for themselves, to ask intelligent questions of experts, and to confront authority confidently" (Steen, *Mathematics and Democracy—The Case for Quantitative Literacy,* Woodrow Wilson National Foundation 2001). Institutions usually adopt or develop QL courses that meet the needs of their own students within the context of the institution's mission and educational goals.

If you find yourself preparing to teach a QL course, take some time to explore and familiarize yourself with the exciting and innovative resources that are becoming available. Turn your mathematics course into a course on social justice or a course on the use of quantitative information in the media. Focus on game theory or integrate an intensive spreadsheet component to your course. Increase active learning by incorporating role-playing activities or community service elements in your QL course. Whatever the focus, work to support quantitative-literate graduates. Most important, make sure that students will never ask the question "When will I ever use this?"

RAWPIXEL/123RF

## Curricular Materials

Bennett and Briggs's *Using and Understanding Mathematics: A Quantitative Reasoning Approach* (Pearson, 2014) has been a go-to text for a number of years. It includes material on critical thinking, numbers in the media, personal finance, probability and statistics, and linear and exponential modeling.

Published in 2016 by the MAA, Bolker and Mast's *Common Sense Mathematics* uses real-life scenarios as they examine, among other topics, estimation techniques, units, absolute and relative change, means, and weighted averages. Many of their examples come straight from media headlines.


MAA's Common Sense Mathematics.

If you wish to focus entirely on news articles, consider Madison et al.'s *Case Studies for Quantitative Reasoning: A Casebook of Media Articles* (Pearson, 2010), which is a collection of newspaper articles together with study questions for students.

Offered through the online platform MyMathLab®, Gaze's *Thinking Quantitatively: Communicating with Numbers* (Pearson, 2015) incorporates numerical literacy, real-world problem solving, and the use of spreadsheets in its approach to QL.

If you are looking to create multiple pathways relevant for different majors, options include the Charles A. Dana Center's Quantitative Reasoning course (http://bit.ly/dana-ql) or the Quantway curriculum maintained by the Carnegie Foundation for the Advancement of Teaching (http://bit.ly/carnegie-ql). Both curricula include a customized prerequisite course that provides developmental students an accelerated pathway to and through their college-level QL course.

A fundamental component to quantitative reasoning is the ability to communicate, orally and in writing, with and about quantitative information. Many existing and emerging QL materials feature activities to support student presentations, projects, or writing assignments. Making room for students to communicate may require faculty to rethink their classroom role and learn about alternative approaches to assessment. It provides a wonderful context in which to think deeply about student learning.

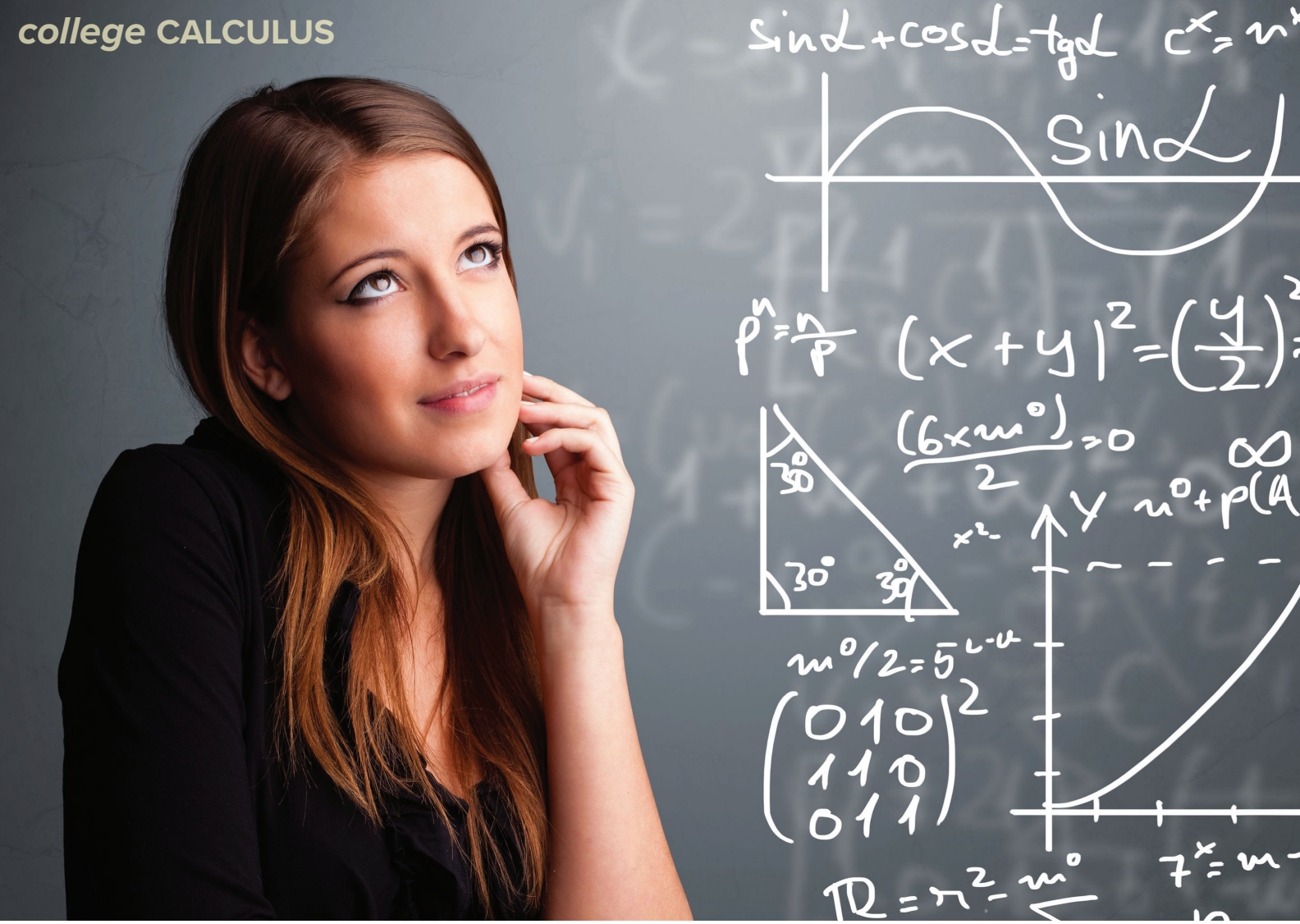
## Resources

As one might expect, student project ideas and descriptions of innovative pedagogy for QL courses can be found on many internet sites. The Science Education Resource Center at Carleton College (http://serc.carleton.edu/nnn/QLprojects.html) hosts an extensive collection of projects from a variety of disciplines and offers a plethora of resources and ideas.

For scholarly writings and research papers related to QL and how to assess QL, peruse the online open-access journal *Numeracy.* Current and future QL instructors should join both the MAA's special interest group on QL (SIGMAA-QL, http://sigmaa.maa.org/ql/) and the interdisciplinary National Numeracy Network (http://serc.carleton.edu/nnn/index.html). Both of these communities offer access to materials, meetings, workshops, and colleagues committed to improving the quantitative literacy of our students and all members of society.

Finally, keep an eye out for an upcoming MAA Notes volume dedicated to QL, which will contain more extensive descriptions of current approaches, philosophy, and resources. Teaching quantitative literacy in our colleges and universities is an important and rewarding endeavor. Get involved now and enjoy the adventure!

*Stuart Boersma is professor of mathematics at Central Washington University and chairs CRAFTY. Caren Diefenderfer is professor of mathematics at Hollins University and past president of the National Numeracy Network. They both have chaired SIGMAA-QL.*



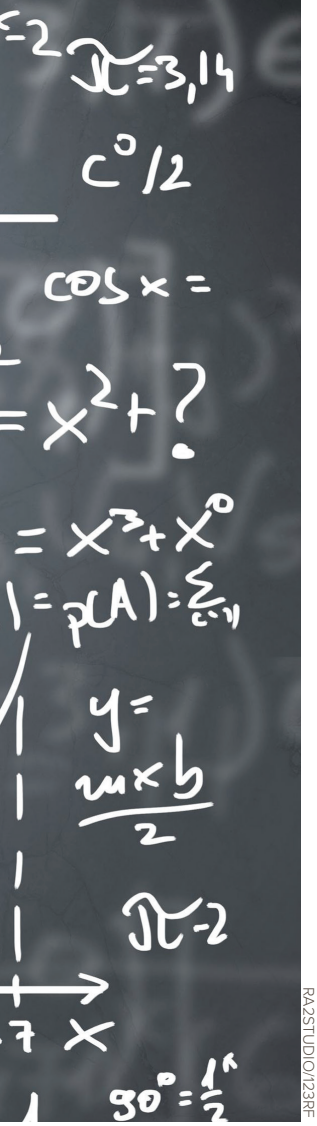
# Women in Math:
# Insights into Lower Persistence

*David Bressoud*

*This article is part of a series on findings from the MAA's NSF-supported studies to determine characteristics of successful programs in college calculus. Beginning in 2009, the MAA undertook a national survey of Calculus I instruction and conducted case study visits to 20 colleges and universities with interesting and, in most cases, successful calculus programs. For details, see the* Insights and Recommendations from the MAA National Study of College Calculus *(Bressoud, Mesa, and Rasmussen, 2015) or visit* maa.org/cspcc.

The MAA's national studies of college calculus received national attention following the publication in July 2016 of the paper "Women 1.5 times more likely to leave STEM pipeline" by Jessica Ellis, Bailey K. Fosdick, and Chris Rasmussen, which appeared in *PLoS ONE.* The story was picked up by the *Washington Post, Huffington Post, U.S. News, Science,* and many other news outlets. The message is that among students who enter Calculus I at the collegiate level with the intention of continuing on to Calculus II, women are 50 percent more likely than men to decide not to continue in the calculus track by the end of that term.

I reported some of the preliminary data on women's rates of persisting in calculus in a *Launchings* column (2014). The work of Ellis, Fosdick, and



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Rasmussen was based on a careful analysis of these data, controlling for a number of variables including level of preparedness, intended career goals, institutional environment, and student perceptions of instructor quality and use of student-centered practices.

Beyond remarking on the differences in the persistence rates, the MAA study Characteristics of Successful Programs in College Calculus asked students for their reasons for switching. They could choose as many as they felt were applicable from six possible reasons (see the table below).

We see that there are no significant differences between men and women until we get to whether they believe they understand calculus well enough to continue, where the difference is significant at $p < 0.05$. The differences are even more dramatic if we restrict our analysis to just those who are earning an A or B in the course. In this case, 18 percent of the women, but only 4 percent of the men, believed they did not understand calculus well enough to continue. And while there were no men in our study who were earning an A or B in Calculus I and felt that their grade was not good enough to continue, 7 percent of the women who were earning an A or B and decided not to continue felt that their grade was still not good enough.

We also discovered that among women heading into engineering who were earning a C in Calculus I, 19 percent decided not to continue with calculus, a decision that closed off the possibility of pursuing a degree in engineering. For men heading into engineering and earning a C in the course, only 7 percent decided not to continue to Calculus II.

These results are consistent with the work of Christopher Strenta et al. (1994) who found significant differences between women and men who entered college with the intention of majoring in science. Women were much more likely to question their ability to handle the course work, and women were much more likely to feel


JORGE CHAM ©THE STANFORD DAILY

depressed about their academic progress.

Why is this happening? A growing number of researchers are investigating the psychology of this problem. They have identified several issues, including sense of belonging and fixed versus growth mind-sets. We live in a culture that does not expect women to do as well as men in mathematics. Women heading into engineering, a physical science, or mathematics are aware of their underrepresentation and so question whether they belong (see the Jorge Cham comic, this page).

When this uncertainty is placed on top of our cultural propensity to see mathematics as an innate skill that one either does or does not possess, there is a strong tendency for women entering mathematically intensive fields to justify their presence on a belief that they are mathematical persons. Anything that shakes this belief, even

| | STEM-Intending | | STEM-Interested | |
|---|---|---|---|---|
| **Reason for not intending to take Calc. II** | **Men** | **Women** | **Men** | **Women** |
| | **(37)** | **(48)** | **(86)** | **(158)** |
| I changed my major and now do not need to take Calculus II | 70% | 65% | 33% | 32% |
| To do well in Calculus II, I would need to spend more time and effort than I can afford | 41% | 35% | 38% | 37% |
| My experience in Calculus I made me decide not to take Calculus II | 32% | 38% | 42% | 45% |
| I have too many other courses I need to complete | 27% | 25% | 50% | 50% |
| I do not believe I understand the ideas of Calculus I well enough to take Calculus II* | 14% | 35% | 20% | 32% |
| My grade in Calculus I was not good enough for me to continue to Calculus II | 16% | 19% | 15% | 15% |

doi:10.1371/journal.pone.0157447.t002

**Table 1.** *Reasons given at end of the term for not continuing on to Calculus II, displayed by gender and by whether the student's intended major, declared at the start of the course, was in a STEM field (STEM-intending) or not (STEM-interested). Source: Ellis, Fosdick, and Rasmussen (2016).*

no longer getting one of the top grades in the course, can ignite doubts about whether one still belongs.

We also now know a lot about how to counter such uncertainties. Simple awareness of these cultural issues and the damage they can do is important. Fostering a growth mind-set is also critical. This means knowing that failure is not a signal of personal inadequacy but rather an opportunity to learn and a challenge to find new ways to engage the mathematics. An easy introduction to what it means to foster a growth mind-set can be found in the blog article "Seven Things Growth Mindset Is Not" by Catherine Good and Michael Regnier (2016). For an introduction to the research on this topic, see David S. Yeager and Carol S. Dweck's article "Mindsets That Promote Resilience" (2012).

*David Bressoud is DeWitt Wallace Professor of Mathematics at Macalester College in Minnesota. He is also director designate of the Conference Board of the Mathematical Sciences.* *Characteristics of Successful Programs in College Calculus was funded by NSF grant 0910240.*

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## Call for Proposals

### Tensor Women and Mathematics Grants

The Tensor Foundation has provided funding for the Mathematical Association of America (MAA) to award grants for projects designed to encourage the pursuit and enjoyment of mathematics among female students.

The objectives of the MAA Tensor Women and Mathematics Program are to encourage college and university mathematics faculty to develop projects to increase participation of women in mathematics; and to provide support to project directors.

Middle school, high school, and beginning college students are targeted for these grants, which may be up to $6,000. College and university mathematics faculty and their institutions may submit proposals. They should collaborate with middle school and high school mathematics teachers as appropriate. Proposed programs may replicate existing successful programs, adapt components of such programs, or be entirely new.

Deadline for Proposals: February 12, 2017
For more information on grants to support women in math, please visit:
maa.org/women-and-mathematics-grants

### Tensor-SUMMA Grants

The Tensor Foundation has provided funding for the MAA to award grants of up to $6,000 for projects designed to encourage the pursuit and enjoyment of mathematics by students who are members of groups historically underrepresented in the field of mathematics. Projects may be designed for middle school students, high school students, or college/university students.

Projects should provide enrichment activities that lead to heightened interest in mathematics and deeper appreciation of it. These projects are not intended for remedial help for students who need assistance in order to succeed in their coursework in mathematics. They should encourage students to continue studies of mathematics in high school and college and should better prepare them for those studies. Undergraduate and graduate students may serve as role models and work directly with students under the tutelage of faculty from both the college or university and middle or high school. Active engagement in doing mathematics is an essential feature.

Deadline for Proposals: February 12, 2017
For more information on grants to support underrepresented minorities in math, please visit:
maa.org/tensor-summa-grants

# Improv-ing a Mathematician's Professional Skills

*Ellen Eischen*

***As we gingerly cut the cadaver, my surgical partner casually remarked that he once checked out a tower of popular math books from the library and spent the entire weekend reading them.***

*ABOVE: Author in a workshop group in Boston (photo courtesy of author). Right: Members of Second City Comedy Troupe aboard a cruise ship (photo by Sean Pavone/123RF).*

"Here's something amazing. The square root of 2 doesn't exist," he announced.

"Yes, it does!" I immediately replied, eager to set the record straight. "The square root of 2 exists. It's just irrational." A few giggles from the front of the room turned into full-fledged laughter as I began to explain what irrational means and why the square root of 2—or any prime number—is irrational. As was soon pointed out to me, I was also enthusiastically stabbing the cadaver as I made each point.

I'm not a medical doctor. In case you think this is the setup for that familiar punchline, no, I don't even play one on TV. I am a mathematician who was engaged in an improvisation exercise in a

class at Chicago's iO Improvisation Theater.

In improvisational theater (commonly called "improv"), the actors ("improvisors") make up everything on the spot. The improvisors take suggestions from the audience (often consisting of just one word) to inspire a scene or series of scenes, without a script and typically without props or costumes. As in the example above where the absent-minded surgeon was overwhelmed mid-operation by a compulsion to clarify the status of the square root of 2 emphatically and enthusiastically, these scenes are often inherently funny.

Although a great improv scene—like a beautiful proof or piece of mathematics—often unfolds naturally, with each step feeling inevitable and effortless, thousands of hours of training go into a top-notch improvisor's preparation. In 2010, I began to learn the fundamentals of improv through a sequence of classes at Chicago's Second City, the famous comedy theater. By the time of the cadaver scene, I had steadily advanced to classes in which most of my classmates were people who aspired to careers in the arts, many of them having moved to Chicago—considered the world's improv capital—explicitly to study improv.

Meanwhile, I—having originally enrolled in improv classes for a brief weekly break from mathematics during my Boas Assistant Professorship at Northwestern University—was struck by how the skills I developed in improv classes were influencing my own professional development as a mathematician. Advantages of improv training for communication and collaboration in a range of professions are well documented (see, for example Lisa Evans's article in "3 Ways Improv Can Improve Your Career" [*Fast Company,* 2014, bit.ly/FC-improv] or Kenneth Chang's "Attention, All Scientists: Do Improv, With Alan Alda's Help" [*New York Times,* 2015, nyti.ms/2ezmQi6]). The benefits for my own career extend far beyond those ones. In particular, I partially credit several of my professional accomplishments—including successful NSF grant proposals, research papers, and a teaching award—to skills I honed in improv classes.

## On the Job

Like mathematicians, top-level improvisors train to become keen observers, to find patterns, and to identify themes and relationships among collections of observations. As we were reminded repeatedly in my improv class at the Upright Citizens Brigade (UCB), "Find the first unusual thing. Explore it. If this is true, what else is true?"

One difference, though, glaringly stands out: Improvisors must create something novel, engaging, coherent, and convincing in the moment. There is no time for debate, fact-checking, imprecision, or revision. Furthermore, taking the idea of a collaboration without an assigned lead a step beyond what most mathematicians would consider workable, improvisors need to be able to assume on a moment's notice any of infinitely many roles (queen of England, sommelier, ring-tailed lemur, etc.) to support their team members. Surprisingly, some of the basic techniques improvisors use to perform under these unique pressures have been particularly helpful to me in my career as a mathematician.

**Research papers and grant proposals.** As someone with a strong inner critic—which is an asset for finding holes in a mathematical argument but also a liability that can impede progress—I have worked through difficult stages of research projects and grant proposals by temporarily turning them into extended improv exercises. I start with "Suppose I were someone who could . . . ," and I internally replay questions my improv instructors would ask to help students assume a character and its accompanying status. I then begin a draft in that mind-set. Using skills from classes, I make specific, definitive statements (a necessity to drive an improv scene—or research program—forward), all the while saying "yes" to my (character's) ideas and building on them without hesitation.

Obviously, starting with a strong and broad knowledge base is crucial. In the cadaver scene, my classmates were delighted that a character was talking competently and happily about mathematics. Many of my classmates told me that (like me) they had never seen a scene before in which someone was enthusiastically explaining math, something that requires integrating prior knowledge.

On the other hand, knowledge is not sufficient. A guided variant of "fake it till you make it" (a phrase that never resonated with me in my professional life, where I look and sound different from most mathematicians), improvising can help one say "yes" to ideas built on genuine knowledge and move forward with creativity and confidence. This has played a crucial role in my drafts of grant

proposals and portions of papers, sometimes turning a burdensome challenge into a fun one.

**Heightened focus and insight.** Even though improv classes left me simultaneously exhausted and exhilarated, I experienced a heightened ability for a day or two afterward to focus and build on new mathematical information quickly and with little effort. (Conversely, I consistently found that immediately after working on mathematics research, my ability to improvise was weakened.) The strength of this change was far stronger than any following my participation in other hobbies or social activities.

Why should having to quickly name eight kinds of cereal or remember a list of names or quickly identify a pattern in my classmates' behavior or rhyme a bunch of words with the name "Bill" while sticking to a theme and rhythm (all parts of common drills) expedite my progress in understanding deep mathematics? Is it just that these exercises (containing no mathematics) are sufficient for priming the brain to focus, look for patterns, and say yes to new ideas without hesitation? A convincing explanation for this improbable-seeming effect is beyond my current level of expertise (even after starting with "Suppose I were someone who had this level of expertise . . .").

**In the classroom and beyond.** In my first 10 hours of improv classes, we rarely spoke. Instead we did silent exercises, many of which are surprisingly effective at increasing empathy between people and even at creating self-awareness of previously unconscious biases. Such awareness is clearly advantageous when teaching (or interacting with anyone).

*You can find improv theaters that offer three- to five-day workshops during summer and winter breaks.*

Here is an example of such an exercise (but without engaging in the exercise yourself, the effect I just described might seem unlikely): Find a partner, face that person, and mirror that person's actions in real time. Then switch roles so that your partner is mirroring your actions. Then switch roles, over and over again, each assuming the role of mirror for shorter and shorter intervals, until it is no longer clear who is the mirror and who is initiating movement.

When we finally began speaking in class, I was aghast to discover how weak a listener I, like most of my classmates, was. Fortunately, simple exercises help develop superior listening and communication skills, another asset for instructors (or collaborators). For examples, see the "yes, and" and "gibberish" exercises below. Once students have mastered those skills, advanced improv classes provide abundant personalized feedback that strengthens their ability to communicate and achieve a desired response in any setting.

*Ellen Eischen is an assistant professor in the Mathematics Department at the University of Oregon. She has completed the iO Theater's Improv Program, as well as Second City's Improv Program. She can be reached at* eeischen@uoregon.edu.

## A Few Sample Exercises

(1) Practice saying "yes, and." As mathematicians, we are trained to look for holes in arguments and can get into the habit of saying "no" to the point of impeding progress. With a partner, practice repeating the last sentence they said and then adding something new and specific to build on it. Go back and forth with your partner for several iterations. Helpful variant for those with a strong inner critic: Practice "yes, and"-ing yourself.

(2) In a team, quickly name three specific strengths or contributions each of your teammates brings to the project. These must be true strengths and as specific as possible.

(3) Try the mirroring exercise from above. Too easy for you? Add dialogue that you have to say in unison. Still too easy? Try doing a scene in which each character is played by two people moving and speaking in unison (an enormously challenging and hilarious exercise).

(4) Using only gibberish (no actual words), communicate with a partner. Have your partner translate it into English. How accurate was the translation, and why?

# Three Mathematicians Walk into a Carriage House . . .

*Katharine Merow*

Although the three mathematicians in the headline didn't visit at the same time, each had plenty of company. A MAA lecture series featuring distinguished experts explaining various aspects of mathematics usually fills up the seats in the MAA's Carriage House in Washington, D.C. Now, the MAA has started live-streaming its Distinguished Lecture series on Facebook, and the numbers show enthusiastic interest. At press time, the three lectures summarized here had each gotten thousands of views.

Visit MAA's Facebook page and click on "Videos" along the left side of the screen. The National Security Agency grant that supported this lecture series is ending, but the in-person and virtual attendance encourage the association to keep bringing speakers to town.

*Lamb*

## Evelyn Lamb: Tasting Hyperbolic Geometry

In preparation for her Distinguished Lecture on September 15, Evelyn Lamb practiced reciting Euclid's fifth postulate all in in one breath: "If two lines are drawn which intersect a third in such a way that the sum of the inner angles on one side is less than two right angles, then the two lines inevitably must intersect each other on that side if extended far enough."

Hyperbolic geometry grew, Lamb explained to a packed Carriage House, from the irksome fact that this mouthful of a parallel postulate is not like the first four foundational statements of the axiomatic system laid out in Euclid's Elements.

In "Visualizing Hyperbolic Geometry" Lamb helped her audience wrap their minds around—and get their hands on—the strange new world that arises from adopting an alternate version of the infamous fifth.

Lamb zipped through 2,000 years of mathematical thought as a preface, generally paraphrased as, "'Ugh, I hate that postulate!'"

Mathematicians' efforts to prove Euclid's fifth postulate had what Lamb considers a felicitous (if ironic) outcome.

"So many theorems about hyperbolic geometry were proved by people who were trying to disprove hyperbolic geometry," she said.

Alternatives to the parallel postulate are often phrased as variations on an equivalent but more comprehensible statement: Playfair's axiom. Playfair states that given a line $L$ and a point $P$ not on $L$, there is exactly one line through $P$ that does not intersect $L$. Change "one" to "none" in this formulation, and you get spherical geometry.

Lamb used a "spherical interlude" to ease her audience out of Euclid-land. Think of Playfair's line as the equator and Playfair's point as the North Pole, for example. All lines—in this case great circles—through the North Pole intersect the equator.

Lamb also illustrated how round food can help us understand spherical geometry. Wrap rubber bands around a grapefruit to form a triangle on its surface, and you can see that, in spherical geometry, the sum of the angles of a triangle exceeds 180°.

In hyperbolic geometry, however, the opposite is true: If, given a line $L$ and a point $P$ not on $L$, there are infinitely many lines through $P$ that do not intersect $L$—this is the hyperbolic version of Playfair's axiom—the angle sum of a triangle is less than 180°.

Food again proves helpful for visualization. Think of a Pringle. Imagine drawing a triangle on the crisp, and you'll realize that it will be "squished in a little bit on the sides."

But how can we represent a space

that looks like a Pringle everywhere? Enter the Poincaré disk. In this mathematical model, hyperbolic space is a disk and "straight lines" are the arcs of circles that intersect the boundary of the disk at right angles. The model defines distance such that the boundary of the disk is infinitely far away.

"You can think of it as there's really thick sand, and the sand gets thicker towards the edges of the Poincaré disk," Lamb explained.

Those fish in Escher's *Circle Limit I* may look to our Euclidean eyes like they're getting smaller and smaller, but they're all the same size.

Physical models can not only convince you of this but also offer what Lamb called a "visceral experience of how much space there is in hyperbolic geometry."

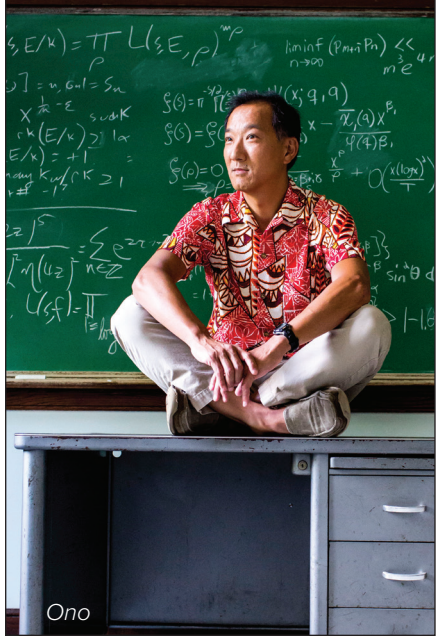
Lamb passed around a "hyperbolic soccer ball" constructed by taping Euclidean hexagons and heptagons together. She showed a photograph of a triangle-and-square construction Berkeley's Katie Mann decorated with Escher-inspired fish.

Lamb's slides included images of "a lot of people's favorite visualization of hyperbolic geometry," hyperbolic crochet, and she brought along her own first foray into the needlecraft. She raved about the impressive twirl of Andrea Hawksley's hyperbolic skirt.

The negative curvature characteristic of hyperbolic space appears often in nature, Lamb observed, in creatures from coral to kale.

Lamb ended her lecture on a speculative note. "Is it just an accident that Euclidean geometry feels so real to us?" she asked. What if we were insects that lived on kale? If we were tiny enough to call a curly vegetable home, and yet retained the mental capacity for mathematics, would hyperbolic have been the first geometry we discovered?

"Would it have been our natural view of the world?" Lamb wondered. "I think that's a fun little thing to think about."


Ono

## Ken Ono: Far from a Dull Number

You probably know the story. Cambridge don and renowned number theorist G. H. Hardy visited his ailing collaborator, Indian transplant and autodidact Srinivasa Ramanujan, in the hospital. Having arrived by taxi, Hardy remarked that its number, 1729, was rather dull. To which Ramanujan replied, "No, it is a very interesting number; it is the smallest number expressible as the sum of two cubes in two different ways."

Ken Ono (Emory University) told a Carriage house audience, "Hardy probably thought, 'That isn't interesting, but it's amazing that Ramanujan happened to know that fact.'"

The standard version of this story, Ono explained during his October 13 lecture, leads one to believe that Ramanujan recognized this extraordinary property of 1729 spontaneously. "Except it's wrong," he said.

Ono did much more than shed new light on the famous tale of the first taxicab number. In "Gems of Ramanujan and Their Lasting Impact on Mathematics," he recounted Ramanujan's life story and drew nonmathematical lessons from it. He described his own involvement in Hollywood's adaptation of Robert Kanigel's *The Man Who Knew Infinity* and showed scenes from the film. In addition to outlining mathematicians' continued efforts to fathom Ramanujan's uncanny insights, Ono also outed Jeremy Irons as an uncoordinated tennis player.

### Two-time College Dropout

Srinivasa Ramanujan (1887-1920) was born in southern India into the priestly caste and remained a devout Hindu to his death. Having developed trigonometry for himself by 13, he soon turned his attention to *Synopsis of Elementary Results in Pure Mathematics,* fleshing out the many details the author's ellipses left to the reader.

"Ramanujan viewed the dot dot dot as a personal challenge," said Ono, who learned of Ramanujan in the 1980s from his number theorist father.

"He told me the story about some Indian dude who died 60 years before who had visions from a goddess who inspired an entire generation of Japanese mathematicians while at the same time not knowing anything about mathematics as a two-time college dropout," Ono recalled.

Though incredulous, the teenage Ono found in the fantastical sounding tale a heartening takeaway. "What I heard was [that] my father looked up to a two-time college dropout," Ono said. "That's what I latched onto."

Those who value class rank and

SAT scores above all else should not discount unconventional paths to success, Ono stressed as he sketched the outline of Ramanujan's biography. Even as Ramanujan's obsession with mathematics tanked his university career, Ono observed, he had benefactors and parents who continued to support him. Today's educational systems are too inelastic, Ono mourned, for financial and emotional backers to give could-be geniuses license to chart their own trajectories.

### Math at the Movies

Everyone needs help, Ono is fond of saying, and, luckily for mathematics, Ramanujan was not afraid to seek it. Of course the unschooled Madras clerk sought help from no less than the most distinguished mathematicians of his day.

"In Ramanujan you have someone who is supremely confident of his skills but at the same time very humble," Ono explained.

Ramanujan wrote to many mathematicians, but the one who read his letter start-to-finish, saw promise in even its more outlandish formulae, and invited Ramanujan to visit him in England was G.H. Hardy—atheist, curmudgeon, and stickler for mathematical rigor.

As the mathematics consultant for *The Man Who Knew Infinity,* Ono helped writer and director Matt Brown figure out how to convey on screen the desperation Ramanujan (Dev Patel) felt working in isolation in India, the struggles of G. H. Hardy (Jeremy Irons) to fully grasp Ramanujan's suggestive yet perplexing scribblings, the men's differing approaches to the advancement of mathematics.

To Ono fell the tasks of explaining to non-mathy people why math might be considered beautiful, of describing "what pure mathematics is to people who really don't care," of coaching Patel and Irons on how to convincingly portray mathematicians.

"I think you would be surprised by how much they know now," Ono told listeners. And if you care to quibble with any of the math in the film, email Ono. "I stand by it completely," he said.

Ramanujan died young, before he had a chance to fully explicate the contents of his notebooks, and mathematicians have been mining the wealth of Ramanujan's writings for decades. That 1729, for example.

"It is not true that Ramanujan saw off the top of his head that 1729 was the smallest number represented as the sum of two cubes in two different ways," Ono said. In 2013 Ono and fellow number theorist Andrew Granville discovered on a page of Ramanujan's notes in a Cambridge archive three rational functions expressed as power series in x the coefficients of which provide near misses to Fermat's Last Theorem for exponent 3. In the bottom corner Ramanujan had written 93+103=123+1, which equals 1729.

It turns out, Ono explained, that Ramanujan had invented ingenious methods about quadratic forms long before math was ready for them. And in 1993—73 years after Ramanujan's death—John H. Conway and W. A. Schneeberger arrived at an almost too-good-to-be-true result known as the Fifteen theorem by revisiting Ramanujan's notes and perfecting his methods.

Though Ono's own work owes much to Ramanujan, during the MAA lecture he matched his eagerness to acknowledge Ramanujan's vast mathematical legacy with a keenness to derive a nonmathematical moral from the mathematician's story. "Talent can be found anywhere," Ono reminded his Carriage House audience, "even in the most unexpected and unforgiving of places. It has to be brought into the light."

## Moon Duchin: A Geometer Examines Elections

Moon Duchin (Tufts University) brought a mathematician's precision of thought to discussion of our often-messy and contentious electoral system. In her October 24 Distinguished Lecture "Math and the Vote," Duchin tempered news of democracy's undeniable shortcomings with hopeful indications of how mathematical interventions might improve current methods of collective choice.

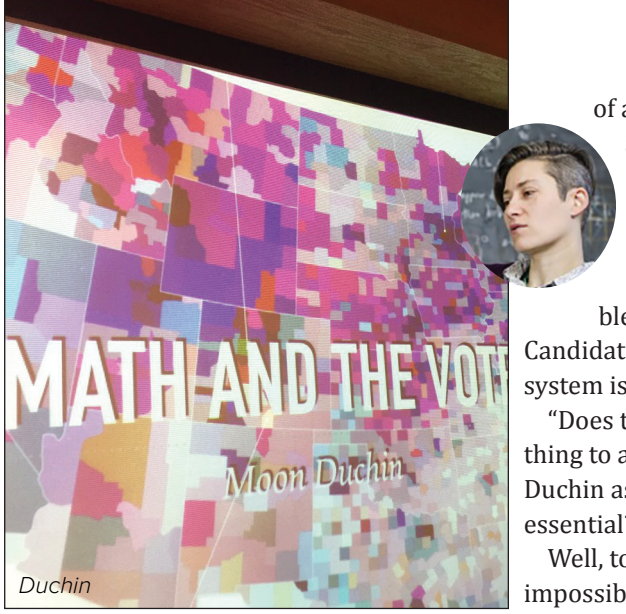
What is an election, Duchin asked, but an attempt to "take the preferences of a whole society's worth of people and aggregate them into an outcome"? And doesn't that sound like a math problem?

Perhaps, but it's a thorny one, as the Marquis de Condorcet recognized in the 18th century. For consider the following preference schedule. (In a preference schedule, the number atop each column specifies how many voters have the preferences in that column.) In the aggregate, these 150 voters prefer A to B, B to C, and C to A. Condorcet observed that, when collective preferences are cyclic like this (as they were in Burlington, Vermont's 2009 mayoral race), no voting system can make a principled choice of a winner.

But what do we mean by "system" exactly? Duchin defined a voting system as a "deterministic algo-

| 50 | 50 | 50 |
|---|---|---|
| A | B | C |
| B | C | A |
| C | A | B |

**Figure 1. A preference schedule.**



Duchin

rithm that takes a preference schedule and produces a winner set" and briefly described a selection of the infinitely many possibilities. Plurality, favored in the United States, declares the candidate with the most first place votes the winner. Most valuable players in baseball—and minority representatives in the Slovenian assembly—are selected via Borda count, a method in which more points are awarded for receiving higher rankings. There's elimination and pairwise comparison and beatpath and the Smith method. Smithified Borda, even.

"And then there's always"—Duchin clicked "Dictatorship" onto her slide and the room erupted in nervous laughter—"in some ways the cleanest system of all, where only one voter counts."

Duchin also surveyed the countless criteria we might expect a voting system to satisfy. Maybe every voter should count the same, or voters should gain no advantage by voting dishonestly. Do you agree that "if a certain candidate is ranked number one by literally everybody then they should win"? If yes, you're in favor of a Pareto efficient system. Do you think that a candidate who wins every head-to-head should win overall? That's called Condorcet-fair. Now suppose you determine the outcome of an election according to your system and then change voter preferences such that each change is either neutral or favorable to Candidate X. If it's impossible for such a change to cost Candidate X the election, then your system is strongly monotonic.

"Does that seem like a reasonable thing to ask from a voting system?" Duchin asked. "Does it seem, maybe, essential?"

Well, too bad. A family of so-called impossibility theorems has established the disheartening fact that no conceivable voting system can meet even a mild list of criteria. The Muller-Satterthwaite theorem of 1977, for instance, states that, given more than two candidates, the only Pareto-efficient, strongly monotonic, single-winner system is . . . dictatorship. Yikes!

Duchin recommends reacting to this revelation flexibly and creatively—like a good mathematical modeler. "Whenever a model produces results that surprise or alarm," she told her Carriage House audience, we should examine the assumptions built into the model and reevaluate their fit. (Does linearly ranking the candidates authoritatively reflect a voter's preferences in a stable way? Try ranking all of this year's primary candidates in a single list to see how difficult it is to capture your views.) Also, there is at least one voting system that satisfies enough criteria for a room full of mathematicians to feel okay employing it: When the Tufts math department votes on a hire, they use beatpath.

## District Division

Duchin devoted the rest of her talk to discussion of apportionment, the division of the electorate into districts that elect representatives. There too, she argued, mathematicians have insights to offer. The Constitution gives surprisingly little guidance on how to divide up states for voting purposes, and the traditional districting principles recognized by the courts can be hard to pin down. We could, however, consult a geometer about, say, how to assess the compactness of a voting district.

"Sometimes the power to draw boundaries is the power to determine outcomes," Duchin noted, also observing that districting has implications for fair representation for minority groups. Too often officials reverse-engineer or gerrymander districts to produce the election outcomes they desire, and we get "ghastly" areas like the Illinois Fourth District 4—nicknamed the "earmuffs"—and North Carolina's 12th District.

"If we're the enemy of tentacles, if we don't want things that are snaky and spread out," Duchin said, we can look for shapes that enclose a lot of area relative to their perimeters. We might award each district an "isoperimetric score" equal to the area of the district divided by the area of a circle of the same perimeter.

She acknowledged limitations of the proposed compactness score, but stressed that now is no time for mathematicians to allow real-world messiness to discourage them from engaging with issues of electoral equity. "There's been an avalanche of changes to voting laws around the country," she said, and "we have to be very vigilant of the impact those new regulations are going to have."

"I would like to think that geometers like me, that math modelers, that algorithmic auditors and a number of different people could get together before 2020 and have some really robust recommendations to make at that time," Duchin said. "That's a goal of mine."

*Katharine Merow is a freelance writer and editor in metropolitan Washington, D.C.*

## PRESIDENT'S MESSAGE

# MathFeed: The Math News App

—Francis Edward Su

**The digital revolution** has brought about sweeping changes in the way we live, teach, do research, and communicate. Just 10 years ago, iPhones didn't exist. Software was shared through CD-ROMs. Videos were watched on TVs. And Facebook was in its infancy.

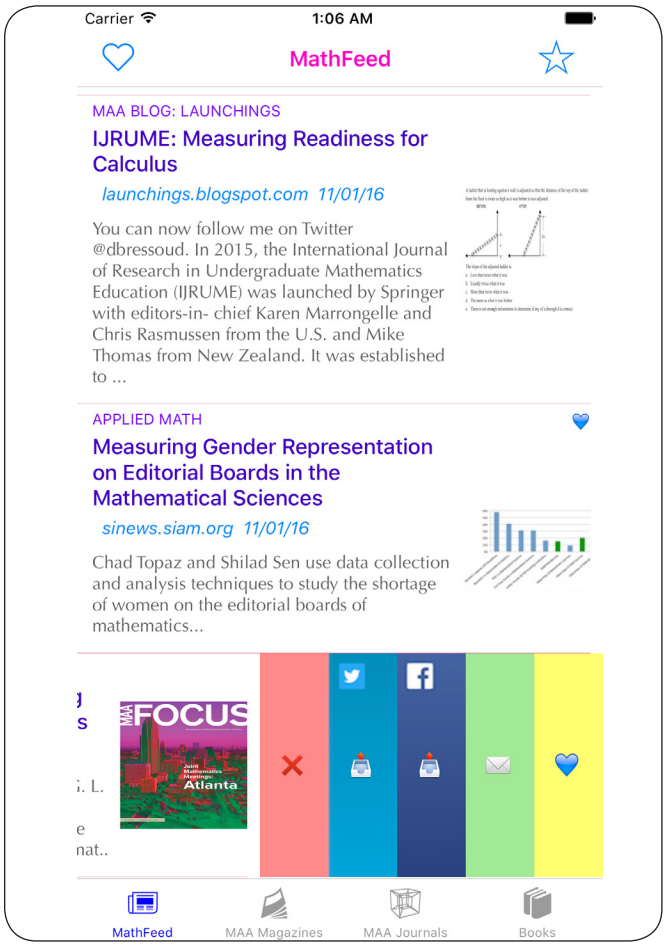
Today, smartphones and mobile devices are at the center of our lives, being a hub through which we consume software, videos, and social media. The change has been rapid. A 2015 Comscore report shows that digital media usage increased 49 percent in just two years between 2013 and 2015, with app usage doubling and accounting for most of that growth. And because of apps, our smartphone is also now our camera, our calendar, our alarm clock, and our music collection.

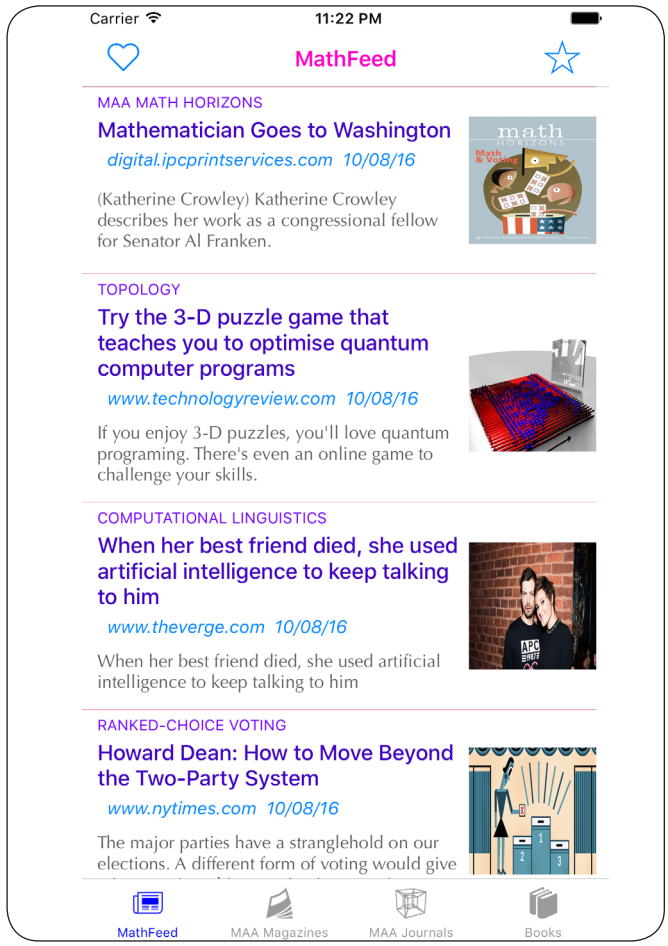
And it is our newspaper. A 2015 Nielsen-Knight study showed that 89 percent of all mobile users seek news through their mobile device. Much of that news comes through social media.

I have been paying attention to the massive shift in how we consume news and to how mathematics is portrayed in the news. At the same time, as more MAA members choose electronic delivery of their journals, I have thought that it would be good to make MAA journals and magazines (even *MAA FOCUS*) more easily accessible on mobile devices through an app, rather than trying to navigate to them through a laptop or mobile browser.

### *MathFeed*

So I'm excited to tell you about a mobile app that I've just completed, called MathFeed. It is a math news aggregator for iPhone and iPad, free



in the Apple App Store.

MathFeed brings together math-related stories and blog posts in a partly curated but mostly automated fashion. Stories showcase the beauty and power of mathematics, as well as its humanity. Stories about statistics and theoretical computer science are also included. And it includes articles from several math professional societies.

There are special tabs for all the MAA journals and magazines: the *Monthly, Mathematics Magazine, CMJ, Math Horizons, MAA FOCUS,* and *Convergence.* For journals that require MAA membership, the app makes it convenient to enter your MAA password once and then never have to enter it again!

You can save articles you like for future reference, and sharing functions make it easy to share articles via Facebook, Twitter, or email. And of course, it is free. Try it out, see how you like it, and tell your friends about it!

For those of you without iPhones: do not worry, there is an Android version coming soon. In the meantime, if you are on Twitter, you can follow *@MathFeed* to see some of the stories that appear in the app.

I have made an effort to diversify the sources that go into MathFeed, but there is a mechanism for you to contribute stories too. Just tweet an article to *@MathFeed,* and it will be considered.

### *My Hopes for the App*

As you see the stories about math that are in the news, I hope you will be inspired to contribute your own talents and expertise to write for traditional news outlets. We mathematicians have a role in shaping public perceptions of mathematics. These could be stories that explain math in ways that are interesting for the public or opinion pieces about mathematics in response to news events. Only a handful of mathematicians are doing this, and I'd like to encourage more of us to try it. But by first seeing what is already out there (good or bad), you will have an idea of the landscape you tread.

Another hope is that MathFeed will be a source of ideas for your students to learn about how mathematics is relevant to their lives. Again, they can follow *@MathFeed* on Twitter if they don't have an iPhone. I'd love to hear how you are using MathFeed in your classes! And, if your department has an MAA membership, this app will help students make the most of their included memberships by allowing them to read MAA products easily.

Finally, I hope that MathFeed will carry MAA products' visibility beyond our membership base. Our journals and magazines are amazing. We have always been the professional society that cares about high-quality mathematical exposition, and more people should know about us!

### *On a Personal Note*

On a personal note, this is my last column as MAA president (though I will continue one more year as past president). I am excited to see Deanna Haunsperger step into the role, and I look forward to the ways in which she will lead our association.

In my time as president, I have attempted to draw attention to broadening our membership base, diversifying the mathematical community, and harnessing the power of the digital revolution in all that we do at MAA.

Some of these efforts took place behind the scenes, in undertaking a careful study of our membership and shepherding the association to think about how to attract junior members of the profession, as well as appointing a task force to advise the association on the social media landscape.

Some of these efforts were more public, in writing several *MAA FOCUS* columns on race and to address issues that adversely affect underrepresented groups in mathematics and an op-ed for the *Los Angeles Times,* titled "Solve This Math Problem: The Gender Gap" (August 25, 2014).

I have also had the great pleasure of visiting many section meetings and seeing all the good things that our members are doing for the mathematics community. You, our members, are the power and strength of our association. You hold the banner high for mathematics and mathematical communication in your roles as teachers, researchers, and practitioners of mathematics, and as mathematical enthusiasts.

I want to invite you to attend my Retiring Presidential Address at the Joint Meetings in Atlanta, where I will be speaking on "Mathematics for Human Flourishing." We can't forget the human element in what we do as mathematicians, and I intend to explain why.

Thank you for the trust you have placed in me these last two years. Thank you for the opportunity to lead the association at the start of its second century. I will remain devoted to you and MAA.

*Francis Su, president of the MAA, is Benediktsson-Karwa Professor of Mathematics at Harvey Mudd College,* su@math.hmc.edu; *Twitter:* @mathyawp.

DEAR MAA

# Visiting Mathematicians Jump-Start Long-Term Projects

*I keep hearing about MAA visiting mathematicians and the MAA mathematician-at-large. Are these real positions?*

*Sincerely,*
*Confused by These Titles*

**Dear Confused:**
*Your question is answered by guest writer Katharine Merow, a freelance writer and editor.*

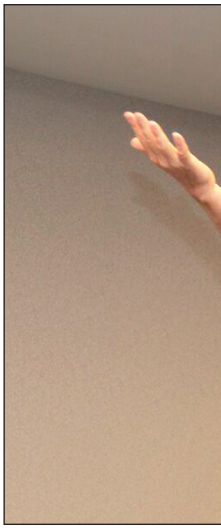
From the outset of her stint as 2016 Dolciani Visiting Mathematician, Adriana Salerno (Bates College) knew her work would extend beyond her September-to-December stay at MAA's Washington, D.C., headquarters. She knew what MAA brass expected of her as she collaborated with staff and committee members to broaden the mathematics community.

"They want us to think about long-term projects and for me to be long-term involved in MAA," Salerno explained her second day on the job. "It's not like I have to change the world in three months."


Salerno

## *Ongoing Projects*

Global change by semester's end may be too tall an order, but the MAA does have a history of harnessing the energies and insights of visiting mathematicians to get new initiatives off the ground. During the six months MAA Deputy Executive Director Doug Ensley, then a professor at Shippensburg University, spent as a visiting mathematician in 2000, he was instrumental in designing and implementing the initial version of the Mathematical Sciences Digital Library. Michael Dorff (Brigham Young University) still directs the Preparation for Industrial Careers in Mathematical Sciences program he worked on at MAA in 2012. Nancy Neudauer (Pacific University), who held the post in 2014, reports a continued effort to secure funding for the project she began outlining while at MAA, Preparing Mathematicians to Educate Teachers II.



James Tanton's experience, however, presents the most extreme example of a semester at headquarters resulting in ongoing involvement with the MAA. Tanton arrived in the fall of 2012 as the first recipient of the Dolciani Visiting Mathematician Grant from the Mary P. Dolciani Halloran Foundation. Awarded every other calendar year for one academic term, the grant was established to provide mathematical sciences facul-

## @MathyAdriana

When Adriana Salerno learned that, as Visiting Mathematician, she'd be following in the footsteps of Tanton, Neudauer, and Dorff, she was flattered.

"These guys are superstars," she says. "I want to be like them when I grow up." The rundown of her predecessors also affirmed Salerno's choice of sabbatical activity. "And then I just thought that this was kind of perfect," she recalls.

Perfect because Salerno cares deeply about the expansion of the mathematical tent that the Visiting Mathematician program is intended to promote. She earned her PhD at the University of Texas at Austin and there, under the mentorship of Michael Starbird, gained an appreciation for inquiry-based learning (IBL) and inclusive pedagogy.

"There's a lot of research showing that active learning strategies are not just good for the kids who are traditionally good but are way more inclusive," she says. "Women and minorities tend to perform better and have better attitudes about math and their own abilities in math."

Salerno applauds the work fellow IBL and active-learning enthusiasts have done at the college level and acknowledges that competitions and Math Circles benefit at least a segment of the K-12 student population. But there's work to be done, she argues, to

*From left: James Tanton, Nancy Neudauer, and Michael Dorff have been MAA visiting mathematicians.*

ty the opportunity to spend several months at the national offices of the MAA and from there contribute to the advancement of K-16 mathematics education.

Tanton used his initial time at MAA to develop the concept for Curriculum Inspirations, which repurposes the content of the American Mathematics Competitions to engage a broader range of middle and high school students in mathematics. Then, having obtained funding from the Akamai Foundation, the Tom & Bonnie Leighton Foundation, and MathWorks, he was able to stay on to develop the project as MAA's "mathematician in residence." A move to Arizona eventually negated the residency component of that title, but Tanton has continued his work for MAA as the association's "mathematician-at-large."

### *Mathematician-at-Large*

Tanton's charge as mathematician-at-large is to negotiate the no-man's-land between the K-12 and college teaching worlds, and he came to that border zone prepared. After earning a PhD in mathematics from Princeton and teaching at the university level for a decade, Tanton joined the faculty at St. Mark's School in Southborough, Massachusetts. There he founded the St. Mark's School Institute of Mathematics, which strives (according to its website) to "provide community outreach of mathematical excellence" and "enhance and promote creative mathematical thinking, awareness, and enjoyment of the subject." Tanton came to MAA just as the association was expanding its K-12 membership program, and he has proven invaluable to that effort.

"I've done—and continue to do—my utmost to introduce the MAA and all the benefits it and its community offers to the high school teaching community," he says.

So what does that look like day-to-day? A one-man math outreach machine, basically.

In addition to continually augmenting and adapting Curriculum Inspirations, Tanton writes books about problem-solving and offers video instruction via Great Courses titles such as "Geometry: An Interactive Journey to Mastery." He represents

turn more kids on to math earlier.

"I think we need to figure out how to make it more inclusive, less intimidating, less competitive, and less perpetuating of that myth that math is for geniuses," she says.

That's a hard problem to get your hands on, so Salerno was pleased when, early in her MAA visit, the White House Office of Science and Technology Policy (OSTP) gave her a concrete goal to work toward by designating October 25 Active Learning Day. OSTP encouraged K-16 STEM educators to spend at least 10 minutes using an active learning technique in their classrooms on October 25, and MAA hoped to engage its membership in the observance in a lively and nationwide way. Salerno, onetime AAAS Mass Media Fellow and established AMS blogger, joined Twitter (*@mathyadriana*) and got to work. *—K. Merow*

the MAA at teaching conferences and public forums, including May 2016's debate with *Math Myth* author Andrew Hacker at the National Museum of Mathematics in New York City.

Tanton travels to schools and teacher groups to offer educators pointers on how to bring problem-solving principles into the classroom, to help them "explore and expand on the wiggle room they have, even if it is only a very tight wiggle at first."

Both students and teachers email him with questions about math and careers, and lengthy exchanges often ensue. Every day for the past six-plus years Tanton (@jamestanton) has sent the Twitterverse an interesting math puzzle in 140 characters or fewer.

"I don't know where the line is sometimes between me just doing this or that as James Tanton or as James Tanton, MAA's mathematician-at-large," Tanton says. "But it is all about supporting joyful mathematics thinking and doing, so wondering about that line is a bit silly."

### *You Next?*

The Mary P. Dolciani Halloran Foundation opted to increase its support for Project NExT rather than extend the grant that funded Tanton, Neudauer, and Salerno, but MAA Executive Director Michael Pearson says the association will not stop bringing member-leaders to D.C.

"I expect that we'll look for opportunities where we have specific projects that could use focused help, and timing that aligns with the professional lives of potential leaders, to continue to have Visiting Mathematicians," he predicts.

Interested parties should contact Doug Ensley to explore possibilities (densley@maa.org).

TOOLKIT

## Plickers: Low-Tech, High Engagement

—Eileen Durand Faulkenberry

**Engaging our students** is an essential part of their success in our classes. An easy way to both engage the students and assess their learning is through the use of technology, such as clickers (see Stowell and Nelson's "Benefits of Electronic Audience Response Systems on Student Participation, Learning, and Emotion," *Teaching of Psychology* [2007]). These student-response systems provide a way to quickly assess and analyze student learning, typically using multiple-choice questions to give the instructor a snapshot of student knowledge. These systems also provide immediate feedback for the learners. However, clickers are expensive, with classroom sets starting at about $600.

Is it possible to have all the advantages of a student-response system without the expense? Yes! I have discovered Plickers—"paper clickers"—a free student-response system that partners a mobile app with paper cards that the students use in place of a traditional clicker device. The instructor downloads the mobile app (available through the App Store or Google Play) to a phone or tablet then prints a set of student response cards from plickers.com.

A great advantage of this system is that the students don't need to download or purchase anything. They simply use their assigned card to respond. Each student-response card has a unique number, and a set of plickers can accommodate up to 63 students per class. Each card has a figure similar to a QR code that has no rotational symmetry (see figure 1) where each side of the card (top, bottom, right, left) represents an answer choice: A, B, C, or D.

Implementing the Plicker system is easy. First, the instructor sets up a class by assigning each student a unique number corresponding to a Plicker card. An instructor can set up as many different classes as needed. Then, the instructor creates questions through the website, building a queue of the questions to scaffold the learning. During the class session, the instructor selects a question on the mobile device while projecting the "Live View" on the website through the classroom computer and projection system. The Live View displays the question with the multiple-choice options (see figure 2).

To answer, the students turn their cards so that the correct answer is at the top of the card and hold the card up. The app on the mobile device scans the cards using the device's camera. The app indicates which students have participated, and the responses immediately appear in the Live View section, providing an

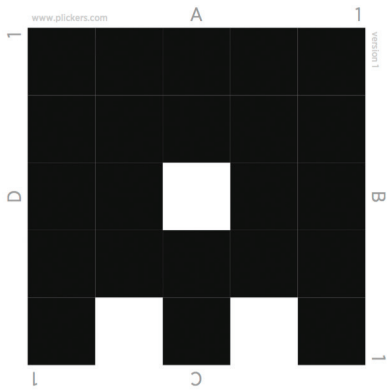



*Figure 1. Example Plicker.*


*Figure 2. Live View on mobile app.*

excellent opportunity for class discussion. There are two options for the Live View–one shows which students have answered; the other shows a bar graph of student responses (see figure 3).

Once a student is assigned a specific card for the course, the instructor can access the data through the website by student or by question and so can use this as an evaluation measure. Additionally, the data can be exported as a .csv file.

## *Practically Speaking*

I teach mathematics and mathematics education courses at a regional university. My class sizes range from 20 to 40 students. I use Plickers as an assessment tool with undergraduates and graduate students to gives immediate, useful feedback; and it provides an excellent springboard for classroom discourse.

Each student receives an assigned folder for the course (a different color for each class to help me stay organized). In the folder, I glue the student's Plicker card. I use these file folders to return any papers to the students and for any handouts they may need during that day's class. The students pick up their folders as they enter the class, remove any papers inside, use the Plicker throughout the class period, and return the folder to the basket when they leave the classroom. This folder system has removed the need to spend time handing out papers throughout the class period and ensures that the students have their Plickers at hand.

I often use Plickers as part of the warm-up activity to see how well students learned the previous day's lesson. I also use them throughout the lesson as a quick formative assessment tool or as a springboard for discussion. I like that the Plickers allow for student anonymity during this time, but I can go to the website after class to determine specific needs of each student based on each one's responses (see figure 4).

I have found that students are much more likely to participate in class when they see on the graph that "many of my classmates had this answer too" and feel more confident to share their solution strategies. The graphs have often started great debates as well, when there are two popular options, providing fodder for excellent discourse.

Plickers provide a low-cost alternative to clicker systems. One of their greatest benefits is how easy they are to use in the classroom. Although Plickers cannot be used for free-response questions, they provide a student-response system that engages the students in learning, provides instant feedback to the learners and the instructor, and promotes classroom discourse.

*Eileen Durand Faulkenberry is an associate professor at Tarleton State University.*

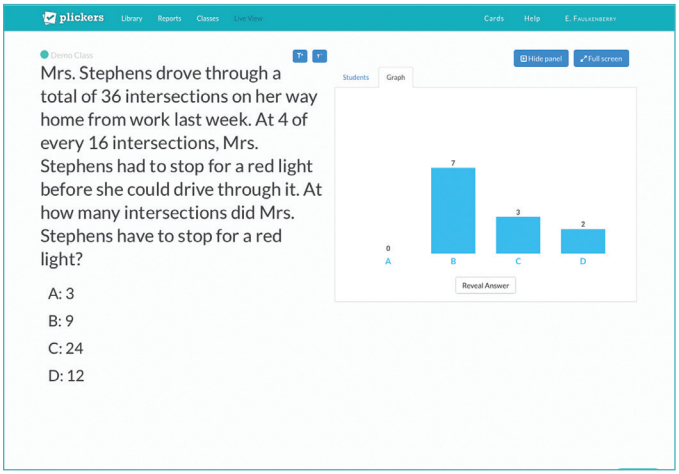



*Figure 3: Live View with graph on classroom*

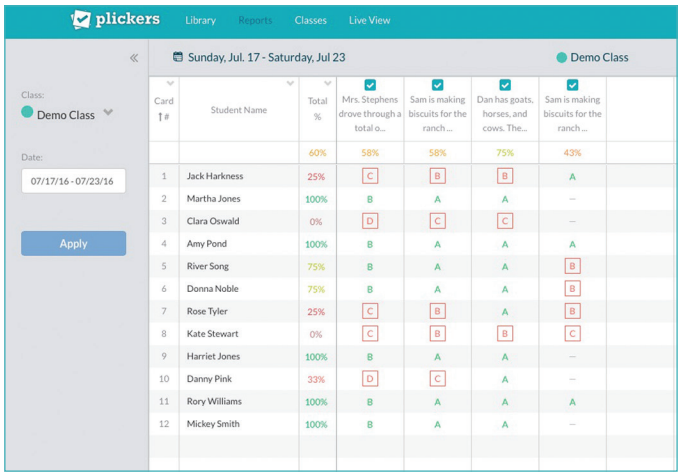



*Figure 4. Scoresheet*

## SECTION HAPPENINGS

# Wisconsin and Seaway Keep Busy

**The Wisconsin section** fulfills its mission by showcasing its members' mathematical outreach and research at its annual meeting, by supporting a vibrant section Project NExT program, and by administering the American Mathematics Competition for middle school and high school students statewide.

### *2016 Section Meeting*

This year's annual meeting in La Crosse, Wisconsin, featured invited addresses by William Dunham (a George Pólya Lecturer of the MAA) and Betty Mayfield (Hood College and MAA Visitor) on the history of math, and an after-dinner talk, "Math and the Movies," by John Beam (University of Wisconsin–Oshkosh).

We were also delighted to host the game show Face Off! where student teams from around the state competed to answer Jeopardy-esque mathematics (and math culture) questions from categories such as "Animated Wordies," "In Verse," and "i-Test." Face Off! is created and produced by Stephen Szydlik and Kenneth Price (both from the University of Wisconsin–Oshkosh). Contact Steve (szydlik@uwosh.edu) if you would like them to bring the fun to your mathematics event.


*Face Off! Team Hilbert bonds before competition at the 2016 section meeting in La Crosse, Wisconsin.*

### *Making a Difference*

The Wisconsin section realizes that we can all make a difference in the mathematical community. Many people in the section are seeking funding to make substantial changes. These are a sample of current projects.

The University of Wisconsin–Eau Claire's (UWEC) Math Department, under principal investigator Manda Riehl, received a $300,000 NSF grant for their Partnership for Undergraduate Research: Enhancing the Mathematics Curriculum, to develop a comprehensive mathematics research emphasis major. The partnership created between UWEC and University of Wisconsin–Milwaukee will engage underrepresented students in research, as well as serve as a model of a sustainable way to increase the number of undergraduates participating in collaborative research.

The University of Wisconsin–Oshkosh (UWO), with PI Eric Kuennen, was awarded a $458,902 Mathematics and Science Partnerships grant from the U.S. Department of Education to provide inservice training to current teachers of upper elementary and middle grade mathematics.

University of Wisconsin–Milwaukee has been recognized by the Society of Actuaries (SOA) as a Center of Actuarial Excellence (CAE). This designation is awarded to programs that meet rigorous requirements related to degree, curriculum, graduate count, faculty composition, graduate quality, appropriate integration, connection to industry, and scholarship. As of January 2016, there were only 30 CAEs worldwide.

### *Project NExT–Wisconsin*

Project NExT–Wisconsin supports the development of between 15 and 20 early-career faculty members as teachers, scholars, and citizens of the mathematical community. Each year the section hosts a fall conference—a retreat-style event where members learn from workshops run by experienced faculty in areas such as the scholarship of teaching and learning (SOTL), history of mathematics, flipped classrooms, and work-life balance. Members are also encouraged to give short talks on topics related to teaching, research, or service. Conference conversations are continued throughout the year via a message board. At the end of each spring section meeting, experienced faculty members on a panel share experiences on a topic selected during the fall conference.

*—Jennifer E. Szydlik*
*Chair, MAA Wisconsin Section*
*University of Wisconsin–Oshkosh*

## Seaway Section

**The fall Seaway Section meeting** on October 21 and 22 had more than 200 registrants, roughly half of which were undergraduate students. So in addition to the usual banquet, plenary talks, contributed talks, and workshops we scheduled two activities specifically aimed at students.

Following the banquet talk on Friday night, it is our tradition to host a game. This is aimed mostly at the undergraduate students, but we often have faculty participants as well. This year, rather than math Jeopardy or a trivia tournament, we borrowed the idea from MAA MathFest (there sponsored by Jane Street Capital) of the "Estimathon." Teams are given quantities to estimate, such as "the volume of Lake Ontario, in cubic feet" or "the number of employees at the University of Rochester," and asked to provide interval estimates to the correct answers. They score points based on whether their interval contains the correct value and how small their interval is.

On Saturday we hosted a panel on "Careers Using Mathematics." Our panelists came from local businesses and industries with careers such as data scientist, actuary, and research analyst. The audience, most of whom were students, peppered the panelists with questions about their careers, how they got them, and advice for how they should proceed with their own. The panelists were able to bring home the messages of "make your career your own" and "keep learning" in order to keep yourself flexible and to enjoy your career.

*—Ryan Gantner*
*Chair, Seaway Section*
*St. John Fisher College*

## MAA BOOKS BEAT

# Browsing the Member Library

—Stephen Kennedy

**Have you been** to your MAA Member Library shelf lately? Do you even know where it is, what it is, and that you have seven free books there?

Your Member Library is the repository on maa.org for ebooks distributed gratis by MAA to you. I'd like to tell you about a couple of the seven books there and about some of our plans for your Member Library.

As a reader of *MAA FOCUS,* you are aware of the MAA's massive investigation Characteristics of Successful Programs in College Calculus (funded by the National Science Foundation). A team of researchers, led by David Bressoud, Marilyn Carlson, Vilma Mesa, and Chris Rasmussen, administered pre- and postcourse surveys to nearly 10,000 students of Calculus 1 at a stratified (by highest degree granted) random sample of nonprofit colleges and universities. They also surveyed those students' instructors before and after the course.

Analyzing the data gathered led the team to identify 20 institutions that seemed to be particularly effective at delivering good results. (Results were assessed by examining a variety of student attitudinal variables, pass rates versus institutional graduation rates, and survey response rates.) Thorough and careful case studies were done at these institutions in an attempt to identify best practices and give shape to the national conversation about calculus instruction (see p. 18 for this issue's installment in a series about the study's results).

I can't possibly do justice to the findings and recommendations of this five-year-long study here. But all the things that you might imagine would matter, do matter: effective placement, good student-support services, a challenging and engaging curriculum, active-learning pedagogies, communities of instructional practice, effective training of teaching assistants, and assessment as a guide to change.

My goal here is to convince you to look at the study. It provides eye-opening perspectives about what is happening in your classroom and nationwide in others' classrooms. And it is full of nuts-and-bolts details (tested and measured for effectiveness) of what folks at institutions like yours are doing to improve calculus instruction.

The study was published in the MAA Notes series—the series where MAA members come together to talk about teaching in a scholarly and professional way. The volumes in Notes are concerned with the teaching of collegiate mathematics. No other publisher would likely print these books, yet it is vital to our profession that they exist and get wide circulation.

In fact, it is so vital that MAA has decided to include all future Notes volumes as a benefit of membership. From now on, when a new MAA Notes volume is released, the free ebook will be placed in your Member Library. Hard copies will remain available on a print-on-demand basis.

A wonderful new MAA Notes volume was recently added to your Member Library: *Beyond Lecture: Resources and Pedagogical Techniques for Enhancing the Teaching of Proof Writing Across the Curriculum.* Editors Rachel Schwell, Aliza Steurer, and Jennifer F. Vasquez have assembled three dozen articles on the topic of teaching proof writing. All kinds of techniques and contexts for improving proof writing are examined: flipped classrooms, portfolios, peer grading, writing circles, and group examinations.

This is a conversation that we need to be having constantly—what are we doing in our classrooms and how can we do it better? MAA Notes is a

unique resource for our community, a place to hold that conversation in a peer-reviewed, scholarly, and professional way.

Our decision to distribute Notes for free means that we are also attempting to reduce the cost of publication. That's one reason we no longer print copies of Notes volumes. Also, we now require that prospective Notes volumes be submitted in the LaTeX template available at maa.org.

**No other publisher would likely print these books, yet it is vital to our profession that they exist and get wide circulation.**

Allow me to get back to your Member Library for one minute. Also posted there is the ebook version of the *CUPM Guide* and a handful of other free ebooks: *Fourier Series* by Rajendra Bhatia, *The Harmony of the World* by Alexanderson and Ross, *The Beauty of Fractals* by Gulick and Scott, and, the MAA's centennial birthday gift to you, *A Century of Advancing Mathematics.* Please download and enjoy them all.

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*Stephen Kennedy (Carleton College) is senior acquisitions editor at MAA. Contact him if you're interested in writing a book for the MAA:* kennedy@maa.org.

## BOOK REVIEW

—Jason M. Graham

**Statistical reasoning** and statistical analysis is universally applicable wherever there is data. Today this seems to be everywhere. Despite the importance of statistics, it seems that for many students attracted to mathematics, statistics courses (even mathematical statistics courses) do not generate the same excitement as does, say, a course in number theory, combinatorics, or dynamical systems. Furthermore, it is not hard to find universities where mathematics courses and statistics courses are taught out of separate departments. Perhaps many mathematicians do not find statistics appealing because, although statistical models may serve great practical purpose, the field appears too applied and unrelated to the development of mathematical theory.

I would argue that this impression of statistics is somewhat inaccurate, since at the level of current research probability and statistics do have deep relations with other areas of mathematics; even the fields of number theory, combinatorics, and dynamical systems (see, for example, Stefano Galatolo, Isaia Nisoli, and Cristóbal Rojas [2014, https://doi.org/10.1017/S0960129512000758]; Kevin McGoff, Sayan Mukherjee, and Natesh Pillai [2015, http://projecteuclid.org/euclid.ssu/1447165229]; and Paul Pollack and Carl Pomerance [in *Erdős Centennial,* 2013]). For more on the interactions between statistics and other areas of mathematics, I also recommend the entry on mathematical statistics in *The Princeton Companion to Mathematics* (2008).

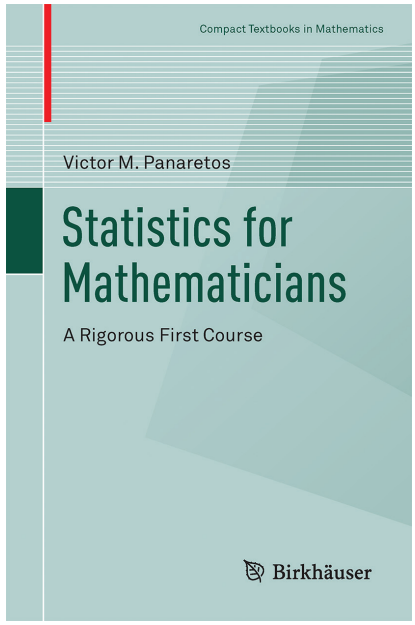
On the other hand, many undergraduate textbooks on statistics seem to be written in quite a different style from texts about other major areas of mathematics. So maybe it should not be surprising that budding mathematicians are often put off by the thought of taking a statistics course or reading a statistics textbook. Victor M. Panaretos has shown that this need not be the case. In fact, in *Statistics for Mathematicians,* he proves that statistics can be presented in a manner that is appealing to many mathematicians.

First off, the material covered in *Statistics for Mathematicians* is elegantly presented, and the text is marked by precise definitions and carefully stated theorems. Consider, for example, the following definition of statistic given on page 41:

Let $X$ be a sample space. Given $n \geq 1$, a statistic is a function $T : X^n \to \mathbb{R}$.

Furthermore, the author introduces the "exponential family of distributions," which simultaneously includes many of the common probability models as special cases and allows one to derive results very cleanly and efficiently. But, the use of precise definitions, abstraction, and mathematical rigor are of limited value unless it leads to better thinking and deeper understanding of concepts, and this is the case in *Statistics for Mathematicians*.

Mind you, rigor and precision are not all that *Statistics for Mathematicians* has to offer. Panaretos makes use of examples, remarks, and other devices to guide the reader to significant understanding of the material. Further, he makes use of beautifully produced figures to illustrate important notions. Moreover, all of this is done with a conciseness that adds to, rather than takes away from, the presentation of the material. I really love this about *Statistics for Mathematicians*: everything the author writes is useful for the readers' understanding of the material. The book also contains many interesting and useful exercises at ideal points in the text to encourage active reading.




*Statistics for Mathematicians*
Victor M. Panaretos
Springer/Birkhäuser
Softcover $49.99
177 pages

One wonderful fact that is clearly illustrated is that many results in statistics can be derived through clever and often beautiful use of calculus. I think that mathematics students, particularly those with an analytical bend, will enjoy *Statistics for Mathematicians.* The main focus of the book is on a rigorous presentation of one-parameter inference. A background in basic probability is assumed, although there is a nice summary of the most important and

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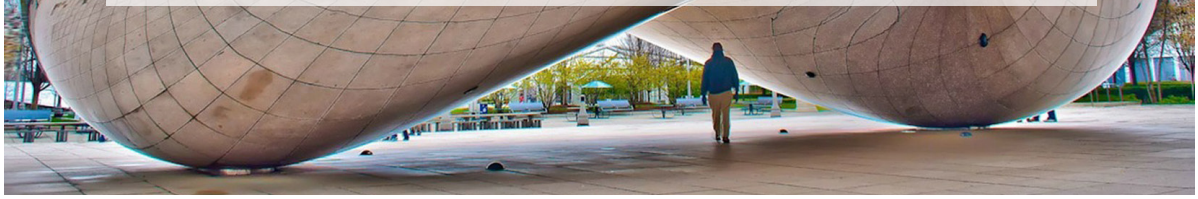

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most relevant results from probability in an appendix. Ideally, the reader of this book should know the meaning of terms such as random variable, distribution, and i.i.d. (independent and identically distributed), but only at the level of a first course in probability that uses calculus.

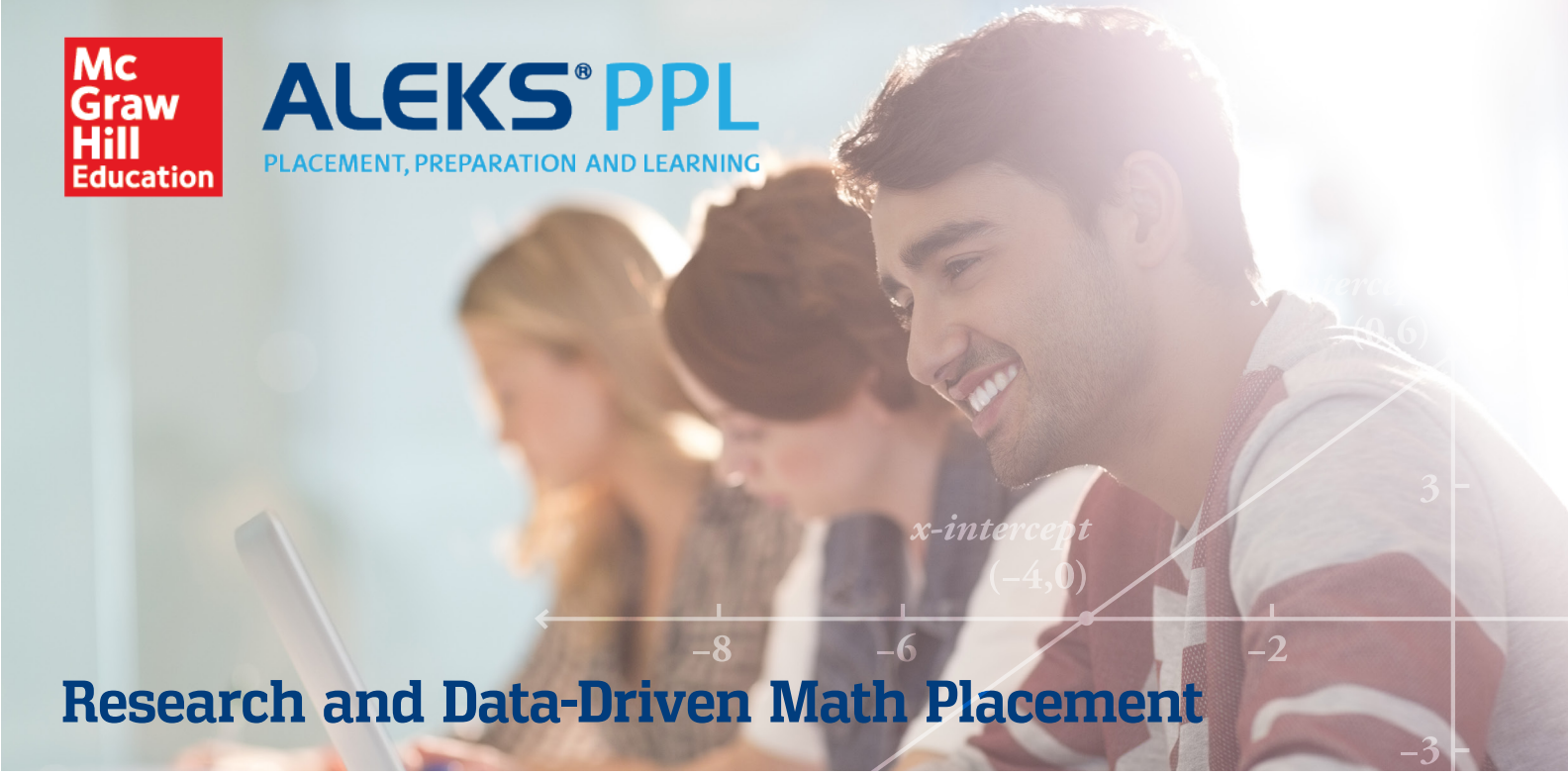
### *Not Perfect for Everyone*

In the opposite direction, *Statistics for Mathematicians* does not contain much at all on the practical analysis of data or the use of computation in statistical modeling. Thus, this book may not serve well for some practically minded statisticians. Nonetheless, I do think that this book captures some of the intrinsic beauty of statistics. Plus, there is a plethora of books on the market that cover all aspects of practical statistics and data analysis.

I think that in writing *Statistics for Mathematicians,* Panaretos admirably achieves his goal "to provide an introduction to the subject tailored to the mindset and tastes of Mathematics students, who are sometimes turned off by the informal nature of Statistics courses."

My only complaint about the book is that it does not contain an index. However, the table of contents is thorough, and all definitions and theorems in the book are highlighted in blue to make them clearly stand out and easy to locate quickly. So, the lack of an index is only a minor issue. Finally, I would like to acknowledge Springer/Birkhäuser for publishing a very well-produced text that is visually appealing and available at a relatively reasonable price.

*Jason M. Graham is an assistant professor of mathematics at the University of Scranton.*

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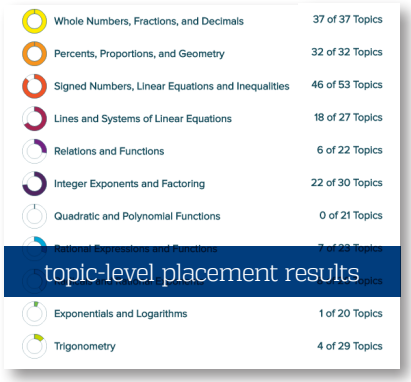


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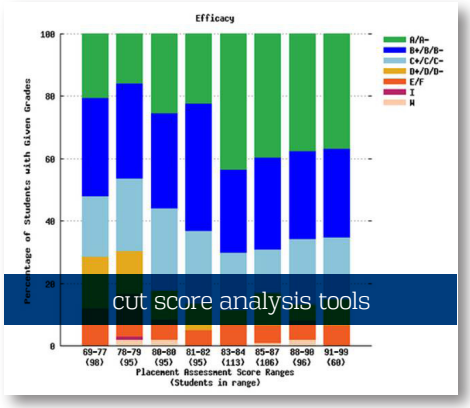
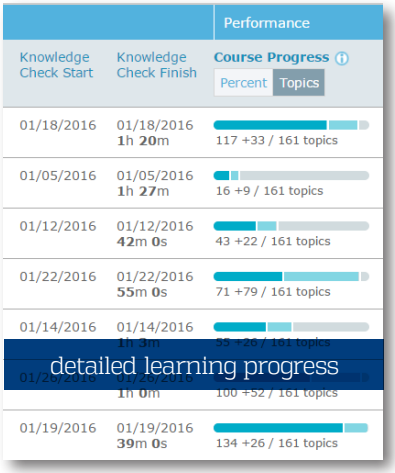



cut score analysis tools

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