MAA FOCUS

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MATHEMATICAL ASSOCIATION OF AMERICA

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From the Editor

Summer is already winding down and we are gearing up for MAA MathFest. By the time most of you read this, MAA MathFest will be underway (or over), and we hope that many of you are with us in Denver for this year's festivities!

With the Aug/Sept issue of MAA FOCUS and the appearance of school supplies in many stores, many of us are beginning to plan our Fall 2018 classes, wrap up summer research and publication goals, and get organized for the new academic year. As you are doing so, think of what classroom innovations you are making, and think about submitting a Toolkit or feature article to MAA FOCUS. We'd love to hear about what you're doing!

As I get ready for the fall semester, the MAA FOCUS editorial board and I are working on outlining upcoming issues. If your section, your SIGMAA, or your university has news to share, let us know! Submissions are always welcome at maafocus@maa.org.

Enjoy the rest of your summer, and best wishes for a great start to your fall!

Jacqueline Jensen-Vallin

On the Cover

Group of math olympians at the event honoring them.

MAA FOCUS

Mathematical Association of America Vol. 38, No. 4 | AUGUST/SEPTEMBER 2018

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MAA MathFest Deadlines

October 31	Priority deadline for Themed Contributed Paper Session proposals
October 31	Minicourse proposals due
October 31	Invited Paper Session proposals due
December 1	Regular deadline for Themed Contributed Paper Session proposals
December 15	Workshop, Panel, Poster, and Town Hall Session proposals due
December 31	Other Mathematical Session proposals due
January 31	SIGMAA Session proposals due

Fall MAA Section Meetings

EASTERN PA & DELAWARE
November 3, West Chester University

IOWA
October 5–6, Morningside College

MARYLAND/DC/VIRGINIA
November 2–3, Mary Washington University

NEW JERSEY
October 27, Montclair State University

NORTH CENTRAL
October 12–13, Southwest Minnesota State University

OHIO
October 26–27, Malone University

SEAWAY
October 12–13, University of Toronto Mississauga

For the most up-to-date information on your section's activities go to maa.org/sections and click on the link for your section. ■

Sign up to Host the Putnam Mathematical Competition in December

Beginning September 1, you can register your campus to compete in the William Lowell Putnam Mathematical Competition, the preeminent undergraduate mathematics competition, on December 1, 2018. Approximately 4,600 students from 580 institutions participated in this highly competitive mathematics exam last year. The highest score on the six-hour exam was 89 out of a possible 120 points, but participation is an honor among mathematics students who value the exploration of mathematical ideas. We invite you to take the Putnam challenge! The 2017 winners can be found at maa.org/2017putnam_winners.

maa.org/putnam

More Advice from Mentors

"Don't get it perfect; get it done." — I. Bernard Cohen

"Nobody can teach well without doing research, though not necessarily for publication. You have to keep learning what's new and how people think about it." — I. Bernard Cohen

"You can't do research just for yourself. You need your peers to keep you honest, to ensure that what you're concluding is based on evidence and soundly argued." — Kenneth Pratt

"Yes, there's discrimination, and yes, you have to fight it. But you also have to be good at what you do."

— Carlos Castillo-Chavez

"Teaching opportunities will walk in through your office door. Service opportunities will walk in through your office door. Research opportunities won't, so you need to go get them yourself." — Judith V. Grabiner

Thanks to Judith V. Grabiner for submitting these quotes.

SCUDEM—Student Competition Using Differential Equation Modeling

SCUDEM III 2018 is a three student team event for high school and undergraduates taking place over the period 19–27 October 2018 with Competition Saturday being 27 October 2018 at local sites in the United States and beyond. Registration is 1 August–5 October 2018 and you can learn more about SCUDEM at simiode.org/scudem. SCUDEM is sponsored by SIMIODE which is funded by the National Science Foundation.

MathPaths Videos Explains the Use of Mathematics to Solve Real-world Challenges

The MathPaths (mathpaths.org/) video series from the University of Texas Dana Center brings mathematics content to life by demonstrating how math is used in today's various workplaces. Watch the videos that feature professionals from a wide variety of STEM fields.

Privacy Policy Update

The MAA has updated its Privacy Policy effective May 11, 2018. These changes were made in preparation for the European Union's new General Data Protection Regulation (GDPR). Review the privacy policy at maa.org/privacy-policy.

JMM Deadlines

September 6	Registration opens
September 25	Abstract submissions due
October 5	Student Poster Session abstracts due
November 1	Student Poster Session acceptance notices sent

Thanks to Representatives Rotating off of MAA Congress

A great big thank you to our colleagues completing their term on MAA Congress on June 30.

James Conklin, *Seaway Section Representative*
Bill Higgins, *Ohio Section Representative*
Charlotte Knotts-Zides, *Southeastern Section Representative*
Jason Molitierno, *Northeastern Section Representative*
Hieu Nguyen, *New Jersey Section Representative*
Jennifer Nordstrom, *Pacific Northwest Section Representative*
Mary Shepherd, *Missouri Section Representative*
Bill Stone, *Southwestern Section Representative*
Joe Yanik, *Kansas Section Representative*

We wish them well and will look for them in new roles with the MAA or their sections.

FOUND MATH

Art Benjamin and Amy Shell-Gellasch found these beautiful wood inlays at an Ethiopian restaurant in Silver Spring, MD. The enlarged photo below (from the inlays along the walls) gives some feeling for how 3D they look in person.

News

Rachel Levy

Introducing the new MAA Deputy Executive Director

The Deputy Executive Director oversees the MAA's extensive portfolio of externally-funded projects as well as ongoing programs such as Sections, SIGMAAs, MAA Project NExT, and the MAA American Mathematics Competitions (AMC) program. Beginning around the time of MAA MathFest (Aug. 1–4, 2018 in Denver, CO), the MAA will welcome a new Deputy Executive Director. Rachel Levy of Harvey Mudd College brings a plethora of experience (from K–12 teaching to university teaching to engaging mathematicians in business, industry, and government) to this position at the MAA. Levy will work with members who serve as project leaders and is the liaison with numerous vendors and constituents of the MAA. We briefly introduce her to you here, and look forward to her future contributions to both MAA and to *MAA FOCUS*.

What was your first experience with the MAA?

I think my first significant experience with MAA was as a Project NExT Fellow. I remember hearing that there was an email listserv that would continue to be an important networking and community-building facilitator for years to come. I still read the emails; I appreciate the questions people ask and ideas that they offer. I look forward to working with the Project NExT leadership team to build our financial resources so that we can welcome and support everyone who wants to participate in the program.

What has been your involvement with MAA since then?

Since starting at Harvey Mudd College, I have written for *MAA FOCUS*, served on the Science Policy Committee, and discussed industry careers with the BIG SIGMAA and the Joint Committee on Employment Opportunities. I have served on the editorial board of *Math Horizons* magazine, served as writer and editor for the MAA Teaching Tidbits blog and served on advisory committees for the CUPM Guide and the Instructional Practices Guide. I co-founded the BIG Math Network, of which MAA is a partner organization. I was honored to be chosen as a facilitator at the Common Vision Meeting and to receive an MAA Alder Award for teaching.

What interested you about the Deputy Executive Director position?

When I first became aware the MAA was searching for a Deputy Executive Director, I spoke with Linda Braddy and Doug Ensley, who both had wonderful things to say about their experiences in the job. Then I started to look closely at the MAA website—it is impressive how much the organization accomplishes! The job will provide new opportunities to think about mathematics education on a national level, and to build collaborative partnerships. We have much work to do, especially regarding diversity, equity, and inclusion.

I am passionate about mathematical modeling education and mathematics communication. I want to improve the way mathematics is represented in the media. I want everybody to see mathematics as something beautiful and powerful that can be found all around them. I want everyone to believe that mathematics belongs to them. I want to support faculty members in all kinds of positions, in all kinds of institutions. I want to improve communication and collaboration about mathematics teaching and learning at all levels.

I believe the MAA has an important role to play with respect to equity. I hope that together we can positively impact the way we communicate about our discipline and our evolving role as critical partners, insightful leaders and approachable innovators. I hope we can improve the representations of mathematicians, mathematics educators and individual attitudes towards mathematics in the popular media as we improve the experience of teaching and learning.

Tell us a bit about your work experience.

My first job was at Learning Disabilities Services at UNC Chapel Hill, followed by a job teaching for eight years at Carolina Friends School Middle and Upper schools in Durham, NC. My first assignment there was teaching 5th and 6th grade math and 9th grade English! Eventually I served as Dean of the Upper School. The Quaker philosophy of the school reinforced my respect for all learners and my love of teaching.

While teaching grade school, I also started providing professional development for teachers in the Durham Public Schools and at NCTM meetings. I mostly facilitated workshops about how to use graphic calculators for (what now would be called) inquiry- and project-based learning and how to facilitate classroom conversations. As side jobs, I was a contractor for SAS Institute working on educational software and in the summer I ran the Duke University Talent Identification Program mathematics program. This work led me to graduate school in Educational Media and Instructional Design and later in Applied Mathematics. My goal was to work on educational mathematics software and textbook development!

Joining Harvey Mudd College (HMC) mathematics department was an unexpected but fabulous detour from my career plan. In addition to teaching mathematics (mostly differential equations), I was allowed to co-teach first-year writing and to co-develop a course on fluid mechanics and photography. This meant I team-taught with a member of each of the six other departments! I continue to be interested in the intersectionality between mathematics and other disciplines, and enjoy the presence of the arts at mathematics meetings.

While at HMC, I continued to work with K–12 teachers and began to focus on mathematical modeling education in elementary school through the NSF-funded IMMERSION program to empower teachers and students. I have enjoyed blogging (Grandma got STEM, American Scientist Macroscope and MAA Teaching Tidbits) and collaboratively writing reports such as one on Undergraduate Applied Mathematics Education and another on Guidelines for Assessment and Instruction in Mathematical Modeling Education (GAIMME).

In addition to administrative experience in the high school and summer programs, I have served as the Society for Industrial and Applied Mathematics (SIAM) Vice President for Education and as the Harvey Mudd College Associate Dean for Faculty Development. I look forward to bringing this administrative experience to MAA, where I will get to support many vital programs, including several that supported me as a faculty member.

What do you enjoy doing outside of work?

I have always loved dancing, singing, boating, and sewing. For a while I did some circus performing and, in the last few years, I have enjoyed mountain biking. I like learning new languages and travelling—the possibilities of destinations in airports make me unreasonably happy on most layovers. In DC, I am excited to explore museums, public transportation and bicycle destinations, and new restaurants with family and friends. Given my NC and GA roots, I have a surprising affinity for humidity (especially if there's iced tea around) so I am even looking forward to arriving in August! ■

News

Dusting Off Your Bookshelf: Geometry

—Kay Smith

In Plato's *Republic,* Socrates states "we know that for the better apprehension of any branch of knowledge, it makes all the difference whether a man has a grasp of geometry or not" (Ronald Calinger, editor. *Classics of Mathematics*, Prentice Hall, 1995, p. 69). Over two millennia later the report of the Geometry Study Group (GSG) contained in the MAA's *2015 CUPM Curriculum Guide to Majors in the Mathematical Sciences* echoed this belief in the importance of geometry: "In no other field can students make such a strong connection between intuition, discovery, proof, and applications. Geometry is built on experiences in the physical and artistic worlds, and in turn is an essential skill in many areas of applied mathematics.... And the geometric viewpoint is central to many current areas of inquiry, from climate science to the mathematics of film-making." In this month's column we focus on books in the Basic Library List (BLL) that relate to recommendations in the GSG's report.

The GSG advocates that every mathematics department offer at least one undergraduate course for mathematics majors devoted primarily to geometry. The BLL contains several possible textbooks for such a course. *Euclidean Geometry and Its Subgeometries* by Edward Specht, Harold Jones, Keith Calkins, and Donald Rhoads provides a rigorous axiomatic development of Euclidean geometry. I. Martin Isaacs uses a more naïve approach in *Geometry for College Students.* William Barker and Roger Howe develop the main ideas about geometric transformations of the Euclidean plane and their applications in *Continuous Symmetry*: *From Euclid to Klein.* For coverage of both Euclidean and hyperbolic geometry see *Geometry Illuminated*: *An Illustrated Introduction to Euclidean and Hyperbolic Plane Geometry* by Matthew Harvey, *Axiomatic Geometry* by John Lee, and *Euclidean and Non-Euclidean Geometries* by Marvin Greenberg.

According to Section 3.1 of the GSG report, students should not only study geometric topics but also "strengthen and extend their visualization proficiency." Books in the BLL support this goal in a variety of ways. *Exploring Classical Greek Construction Problems with Interactive Geometry Software* by Ad Meskens and Paul Tytgat and *Exploring Advanced Euclidean Geometry with Geogebra* by Gerard Venema incorporate activities using geometry software. In *The Universe of Conics* by Georg Glaeser, Hellmuth Stachel, and Boris Odenahl and *A Mathematical Space Odyssey*: *Solid Geometry in the 21st Century* by Claudi Alsina and Roger Nelsen, numerous figures enhance the presentation of topics not usually encountered in contemporary undergraduate curricula. Roger Nelsen's *Cameos for Calculus: Visualization in the First-Year Course* and James Callahan's *Advanced Calculus: A Geometric Approach* use geometry to motivate and illustrate calculus concepts. Two other books by Alsina and Nelsen, *When Less is More*: *Visualizing Basic Inequalities* and *Math Made Visual*: *Creating Images for Understanding Mathematics*, discuss methods for creating figures to "prove" mathematical relations.

The GSG additionally recommends (Section 3.1) that majors learn about the discovery of non-Euclidean geometries, which "changed the human understanding of the relationship between mathematics and the real world." Several books in the BLL address the history of this period. Two textbooks, *5000 Years of Geometry* by Christoph Scriba and Peter Schreiber and *Revolutions of Geometry* by Michael O'Leary, survey the history of geometry from ancient times to the twentieth century. Jeremy Gray's *Worlds Out of Nothing* focuses on the history of geometry in the 19th century. The works of three principal contributors to the development of hyperbolic geometry are presented in *Euclid Vindicated from Every Blemish* by Gerolamo Saccheri, edited and annotated by Vincenzo DeRisi; *Lobachevski Illuminated* by Seth Braver; and *János Bolyai, Non-Euclidean Geometry, and the Nature of Space* by Jeremy Gray.

Finally we mention a few geometry books in the BLL that are appropriate for pleasure reading: *Treks Into Intuitive Geometry* by Jin Akiyama and Kiyoko Matsunaga; *Shaping Space*: *Exploring Polyhedra in Nature, Art, and the Geometrical Imagination*, edited by Marjorie Senechal; and *The Perfect Shape: Spiral Stories* by Øyvind Hammer.

These books are a small subset of the geometry books in the BLL. Check out the books on your favorite area of geometry at maa.org/bll. ■

Kay Smith, a member of the BLL Committee, retired in 2017 after 37 years on the mathematics faculty at St. Olaf College.

The Board of Directors has oversight responsibility for all activities of the association including setting policies and directions for activities; receiving reports from the officers, committees, and senior staff; and exercising fiduciary responsibility.

Congress represents MAA membership by advising on long-term goals and strategic priorities while serving as a conduit for communication between the national organization and its many constituencies.

Care and Feeding of Your MAA Congressional Representatives

— Melissa C. Erdmann and Jennifer J. Quinn

Since its inception in 1915, MAA has been a member-driven association. On January 7, 2017, our membership approved new association bylaws thereby creating the Board of Directors and the MAA Congress. As an MAA member, Congress is *your representative body*—a new and exciting role for leaders in the association. The past year and a half has been spent creating a shared understanding of what this means for Congress, for members, and for MAA as a whole. The time is right to move from discussion to implementation. By following three simple steps outlined below, we can work together to help MAA Congress thrive.

Step 1: Know your Representatives

The 50 members of Congress come from education, academia, business, and industry; they are at different stages of their professional careers; they represent geographical regions, special interests, and MAA leadership. The one thing that they all have in common is a passion for and dedication to MAA.

Much like the United States Congress, you have several representatives in the MAA Congress. Only one however depends on your location. You elect a Section Representative every three years. The 29 Sections account for just over half of the Congress's makeup. The remaining members include chairs of MAA Councils, members of the Board of Directors (where your votes determine the President, Vice President, and President-elect or immediate past President), and Representatives-at-Large for Teacher Education; for Business, Industry, and Government; for Minority Interests; for High School Teachers; and others.

To confirm who your representatives are, visit the Board of Directors page on the Council and Committees List of the MAA website. Look below the Board of Directors and "show" the Congress listing (bit.ly/2yg8opE).

Step 2: Educate yourself about MAA

Find out what is happening at MAA. To start, the MAA website (maa.org) is a treasure trove of information ranging from news of the association to announcements of opportunities and resources, including the recently released *Instructional Practices Guide*. You will also find dates and deadlines for upcoming events such as contest registration, Project NExT applications, and future meetings. When participating in national or regional meetings, consider attending a business meeting or if you have a particular concern or interest, an associated committee meeting. Most committee meetings, including Congress and Section Officers meetings, are open to the public. Informal discussions with your representative, whether in the exhibit hall, over coffee, or anywhere else, are strongly encouraged. Finally, valuable information comes through MAA MathAlerts, in your section newsletter, and in *MAA FOCUS*. As you have read the article this far, you probably already know that.

Step 3: Engage with your Representatives

Congressional representatives work to support MAA's mission "to advance the understanding of mathematics and its impact on our world" by bridging communication between their constituents, the Board of Directors, and MAA senior staff. Fluid communication is crucial so that all voices can be heard.

If you are passionate about mathematics as an intellectual endeavor, its teaching and learning, or the communities we form centered on our common mathematical interests—whether grounded in joy or concern—let a representative know. How else can they discern and advocate for the needs of their constituents? Your input informs their discussion and their discussion impacts decisions. For example, at the 2018 Joint Mathematics Meeting in San Diego, Congress animatedly debated a proposed values statement. These values, along with MAA's mission and vision, are to be used by the Board and staff when setting priorities and determining actions—in effect, influencing every decision that gets made.

At MathFest 2018, Congress will be asking questions like: Whose voice is missing from our representative body? What issues in mathematics, education, or employment are of the greatest concern to our members? How can we facilitate and support engagement on critical issues throughout the year by all members, even those who do not attend meetings? Look for a follow-up article after MathFest to learn more about Congress's priorities for the coming year. Better yet, contact a representative and share your ideas, so your voice is represented. ■

Melissa Erdmann is the Representative from MAA's Nebraska-SE South Dakota Section and Recorder for the Congress. Jenny Quinn is the Congress's Officer-at-Large to the Board of Directors and the Chair of the Council on Publications and Communications.

News

Top High School Math Olympians Announced by MAA American Mathematics Competitions

Nineteen top high school math students were honored June 4 during a ceremony in Washington, D.C. More than 300,000 students participated in the MAA American Mathematics Competitions (AMC), organized by the Mathematical Association of America (MAA) which culminates in the USA Mathematical Olympiad, the final invitational exam in a challenging series of MAA AMC competitions. The winners of the 47th Annual United States of America Mathematical Olympiad (USAMO), 12 high school students with the top scores in the competition, were announced at the event.

European Girls' Mathematical Olympiad

The ceremony also honored the members of the U.S. team that competed in the 7th Annual European Girls' Mathematical Olympiad in Italy this April. The team, which is organized and trained by the MAA American Mathematics Competitions, took second place in the international competition against teams from 52 countries. Team members included Megan Joshi, Wanlin Li, Emily Wen, and Catherine Wu.

The members of the EGMO team (Wanlin Li, Catherine (Katie) Wu, Emily Wen, Megan Joshi) and Deanna Haunsperger.

Special Awards and Prizes

This year, the MAA would like to extend a special thank you to Mr. Robert P. Balles for extending his generosity to include all of our talented honorees.

Samuel L. Greitzer/Murray S. Klamkin Award for Mathematical Excellence: Michael Ren

Robert P. Balles Annual USAMO Prize: USAMO Winners

Robert P. Balles Annual EGMO Prize: EGMO Team

Robert P. Balles Annual Mathematics Award: IMO Team

Akamai Foundation Scholarship Awards

First Place: Michael Ren

Second Place: Thomas Guo, Vincent Huang, Joshua Lee, Mihir Singhal

Sponsors

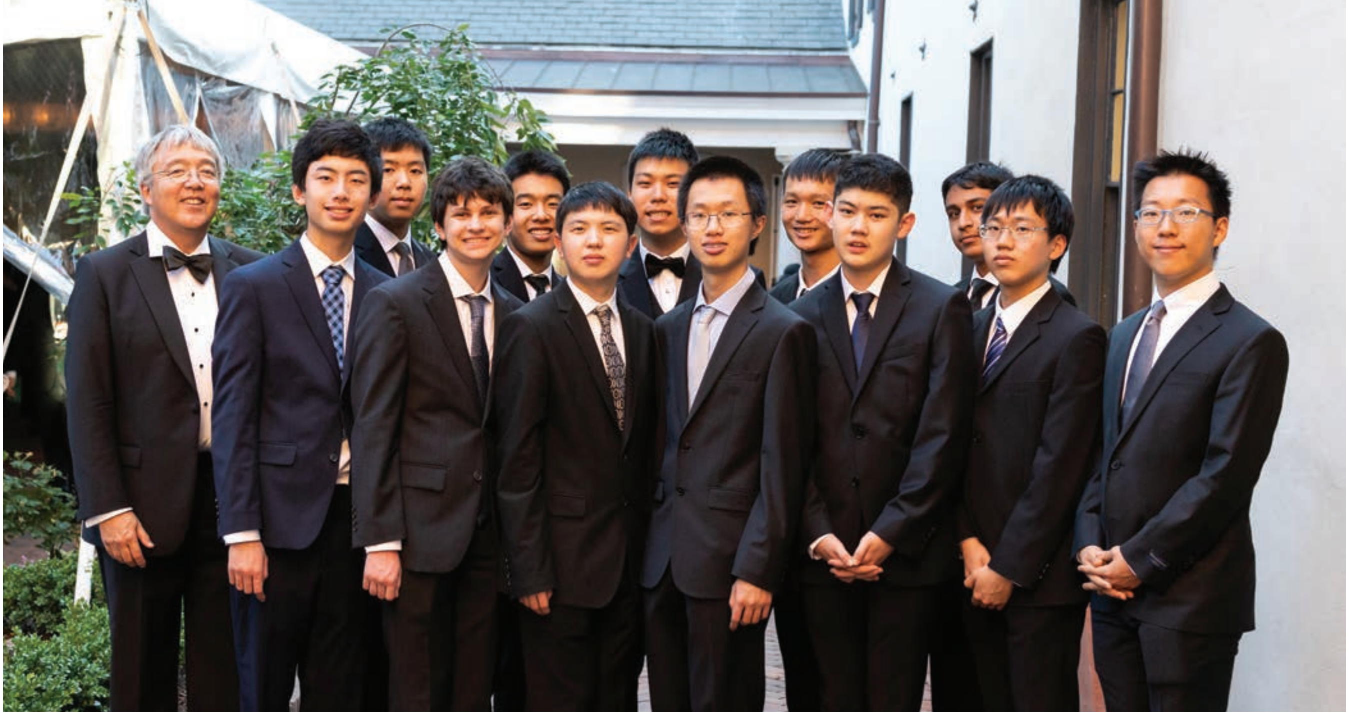
The MAA would like to thank the generous supporters of the AMC program:

Akamai Foundation
The D. E. Shaw Group
Two Sigma
MathWorks
Tudor Investment Corporation
Art of Problem Solving
Jane Street Capital
American Mathematical Society
Ansatz Capital
Army Educational Outreach Program
American Statistical Association
Casualty Actuarial Society
Conference Board of the Mathematical Sciences
Mu Alpha Theta
Society for Industrial and Applied Mathematics

International Mathematical Olympiad

At the June 4 event, the MAA also announced which students will compete on the U.S. team that it organizes and trains for the International Mathematical Olympiad. The 2018 U.S. International Mathematical Olympiad team is: Adam Ardeishar, Andrew Gu, Vincent Huang, James Lin, Michael Ren, and Mihir Singhal. Gu, Huang, and Lin are returning team members from 2017.

"The Mathematical Association of America honors each math olympian for their hard work at the highest levels of high school math competitions. We congratulate these top math students on their achievement on the national and international stage and are proud to organize their participation through the MAA American Mathematics Competitions," said Michael Pearson, the executive director of the Mathematical Association of America. "We look forward to



Jim Kurose and the USA Mathematical Olympiad winners.

their future success as they develop as leaders in diverse fields that increasingly rely on quantitative skills to address issues critical to the future of society."

USA Mathematical Olympiad

The 2018 USA Mathematical Olympiad winners are (in alphabetical order): Eric Gan, Thomas Guo, Vincent Huang, Joshua Lee, Michael Ren, Victor Rong, Carl Schildkraut, Mihir Singhal, Edward Wan, Brandon Wang, Guanpeng Xu, and Andrew Yao. Singhal returns for his third USAMO win and Ren, and Rong were among the top twelve scorers in 2017. The honorable mentions for this competition are available at bit.ly/2IbeGxq.

USA Junior Mathematical Olympiad

The winners of the United States of America Junior Mathematical Olympiad (USAJMO), who are the top MAA American Mathematics Competitions students in 10th grade and below were also announced June 4. They are Ankit Bisain, Andrew Cai, Yunseo Choi, Sebastian Jeon, Benjamin Kang, Arav Karighattam, Jeffrey Kwan, Huaye Lin, Maximus Lu, Samuel Wang, and Benjamin Wright. The honorable mentions for this competition are available at bit.ly/2JUR1PA. ■

GET MORE

More than 300,000 students participated in all levels of the MAA AMC, which culminates in the USAMO. Do you love creating math problems? The Committee on Competitions is always looking for volunteers. Reach out to Bela Bajnok for details at amcdirector@maa.org. Interested in hosting the AMC 8 or 10/12 at your college or university for your local school district? Contact Jennifer Barton at jbarton@maa.org or register today at amc-reg.maa.org.

Team USA Returns to First Place in Olympics of High School Math

The U.S. team won first place for the third time in four years at the 59th International Mathematical Olympiad (IMO) which took place in Cluj-Napoca, Romania on July 3–14, 2018, with 116 countries participating. Prior to a fourth place finish in 2017, the U.S. IMO team won first place in 2015 and 2016 in the prestigious international competition. In 2018, the International Mathematical Olympiad brought together the top math students from around the world with 615 student competitors.

The six U.S. team members (Adam Ardeishar, Andrew Gu, Vincent Huang, James Lin, Michael Ren, and Mihir Singhal) took home five gold medals and one silver medal for their individual high scores in the competition. The first place U.S. team score was 212 out of a possible 252 points. The teams from Russia and China took second and third place, respectively, in cumulative team scores.

"We are very happy to place first for the third time in four years, highlighting our country's consistent mathematical talent and problem-solving capabilities among our high school students," said Michael Pearson, executive director of the Mathematical Association of America. "This shows the strength of the MAA American Mathematics Competitions to build the problem-solving skills that students will use in the future to positively impact society."

Students qualify for the U.S. IMO team by participating in a series of competitions provided by the MAA American Mathematics Competitions (AMC). More than 300,000 students participate in the MAA AMC each year.

The team was accompanied by coach Po-Shen Loh, professor of mathematics at Carnegie Mellon University, and deputy coach Sasha Rudenko, a graduate student at Carnegie Mellon University.

News

The MAA Mathematical Olympiads Awards Ceremony honors 19 Top Performers

On June 4, 19 students, together with parents, mentors, coaches, and representatives of the many supporters of the MAA American Mathematics Competitions (AMC) program, gathered at the historic Decatur House just steps from the White House in Washington, DC, to celebrate the accomplishments of these math Olympians.

During the 2017–2018 contest cycle, the MAA AMC program had over 300,000 middle and high school participants from around the world. Approximately 5,000 were invited to participate in the American Invitational Mathematics Examination (AIME) and 400 in the USA Mathematical Olympiad and Junior Mathematical Olympiad. This year, we've already sent successful teams to the Romanian Masters of Mathematics and the European Girls' Mathematical Olympiad, and by the time this article appears, we will have sent the US Team to the International Mathematical Olympiad in July.

As MAA President Deanna Haunsperger noted during her introductory remarks, "these students are representative of the tremendous mathematical talent that so many in this room work throughout the year to nurture and support, through the MAA American Mathematics Competitions program, as well as programs of other organizations designed to challenge and engage students to develop the mathematical skills that are so important to the future of our increasingly technological and data-driven world."

We were also joined at the June 4 awards event by Jim Kurose, who is currently serving as Assistant Director for Artificial Intelligence at the White House Office of Science and Technology Policy. Dr. Kurose congratulated the students on behalf of the White House. He also encouraged the students to look towards the future and said "I know that you will all continue to sharpen your mathematical skills in the coming years. And I know, too, that these skills are becoming ever-more important in our modern world. Whether managing and interpreting data to assist with critical decisions in areas as diverse as finance and health care, or designing the next mission to explore Mars (or beyond), mathematics will be front and center. We look for you and your peers to be leaders in developing the tools of the future to understand, manage, and explore our world, our solar system, and indeed the entire universe."

The students honored at this year's Awards Ceremony included the 12 top performers on the 2018 USA Mathematical Olympiad, the four members of the US team to the European Girls' Mathematical Olympiad in Italy, and the six members of the team who recently represented the US at the International Mathematical Olympiad in Romania. The students and their awards along with the sponsors of the AMC program are listed in the sidebar to this article.

In addition to the evening event, the students were welcomed at the National Science Foundation (NSF) that morning by Joan Ferrini-Mundy, who became president at the University of Maine this July, after serving as the chief operating officer at the NSF. Dr. Ferrini-Mundy, along with program officers from the Division of Mathematical Sciences and the Division of Undergraduate Education, encouraged the students to learn more about the role of NSF in supporting STEM research crucial to our nation's future, and to look forward to opportunities to engage with the NSF to support their future work.

MAA Executive Director Michael Pearson noted that "mathematics is central across all STEM disciplines for which NSF support is essential. In particular, our efforts are vital to address the ten 'big ideas' that NSF has identified as priorities."

The morning event, as well as the evening awards ceremony and banquet, were fitting ways to both recognize the success of these young mathematicians, and to celebrate the contributions of so many who make the MAA American Mathematics Competitions program possible.

Deanna Haunsperger brought the day to a close by thanking the parents, mentors, coaches, and sponsors one last time for the central role they play in the students' success. "We look forward to following their future success in the mathematical community and beyond. I know you will all join me in wishing these talented students well on their future endeavors."

And we all look forward to welcoming them as members of the MAA and the broader mathematical sciences community! ■

The American Institute of Mathematics Announces the Alexanderson Award

Jerry Alexanderson

The American Institute of Mathematics (AIM) is pleased to announce the first annual Alexanderson Award, given in honor of Gerald Alexanderson, Professor of Mathematics at Santa Clara University and founding chair of AIM's Board of Trustees. Jerry's leadership has extended nationally, contributing to the work of both the Mathematical Association of America (MAA) and the American Mathematical Society (AMS).

The Alexanderson Award recognizes outstanding scholarly articles arising from AIM research activities that have been published within the past few years. Receiving the first award are Alexei Borodin, Ivan Corwin, and Patrik Ferrari for their article "Free energy fluctuations for directed polymers in random media in 1+1 dimensions," *Communications in Pure and Applied Mathematics*, 67 (2014), 1129–1214 (MR3207195). This work began during the October 2011 AIM workshop "The Kardar-Parisi-Zhang equation and universality class." The paper concerns the extreme behavior of certain models for polymers; these are long chains of molecules that occur in nearly every manufactured product. The authors discovered that the behavior of such polymers is governed by universal laws, including the Tracy-Widom distribution and the Kardar-Parisi-Zhang equation. These results may have implications in the fields of physics, engineering, materials science, biology, ecology, and other areas.

Jerry Alexanderson

A member of the Santa Clara faculty since 1958, Jerry has served his institution and the broader mathematics community in various capacities. During this time, he was chair of the mathematics department for 35 years and a member of the Faculty Senate Council. For 38 years, he held the endowed Valeriote Professorship of Science chair. Known as an inspiring teacher and popular author, Alexanderson has cultivated a passion for problem solving and has promoted creative mathematical thinking as longstanding Associate Director of the prestigious William Lowell Putnam Competition. He is author of 19 books, including textbooks in abstract algebra, as well as discrete and combinatorial mathematics. Alexanderson was the first recipient of Santa Clara University's Bayma Award for Scholarship, and he received the Special Appreciation Award from the Dean of Arts and Sciences as well as the Special Recognition Award for Teaching, Research, and Service from the President of the university. In 2005, the significant impact of Jerry's extraordinary teaching success beyond his home institution was recognized with the Haimo Award from the Mathematical Association of America.

Alexanderson's influence has extended to the national level, where he has played a leading and lasting role in the Mathematical Association of America (MAA). His contributions to the MAA have spanned more than 50 committees and 24 years on the Board of Governors, encompassing secretary, vice-president, and president of the Association and editor of *Mathematics Magazine*. Results of this work include the remodeling of the MAA Carriage House in Washington, D.C., into its Mathematical Sciences Conference Center. In this time, Jerry served on the Science Policy Committee of the American Mathematical Society (AMS) and was a consultant to the Editorial Board for the *Bulletin of the AMS*. In testament to his expansive record, Alexanderson received the MAA's most prestigious award for distinguished service to mathematics, the Yueh-Gin Gung and Dr. Charles Y. Hu Award. Noted for his stewardship and as a mentor to many in the mathematics community, Jerry was instrumental to the success of the American Institute of Mathematics as an international center for collaborative mathematical sciences research.

A special celebration for the first Alexanderson Award will be held at Santa Clara University on Wednesday, December 12, 2018. The event will include a public talk by Persi Diaconis of Stanford University, followed by a reception for the award recipients. ■

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Improving Success Rates of Academically At-Risk Students in First-Year Math Courses

Melisa Hendrata and Suzanne McEvoy

Many of us have taken extensive training in teaching pedagogy to make our math lectures more comprehensible for the students. However, how can you improve the success rates if the majority of the students are underprepared in math and are at-risk for academic failure in the first place?

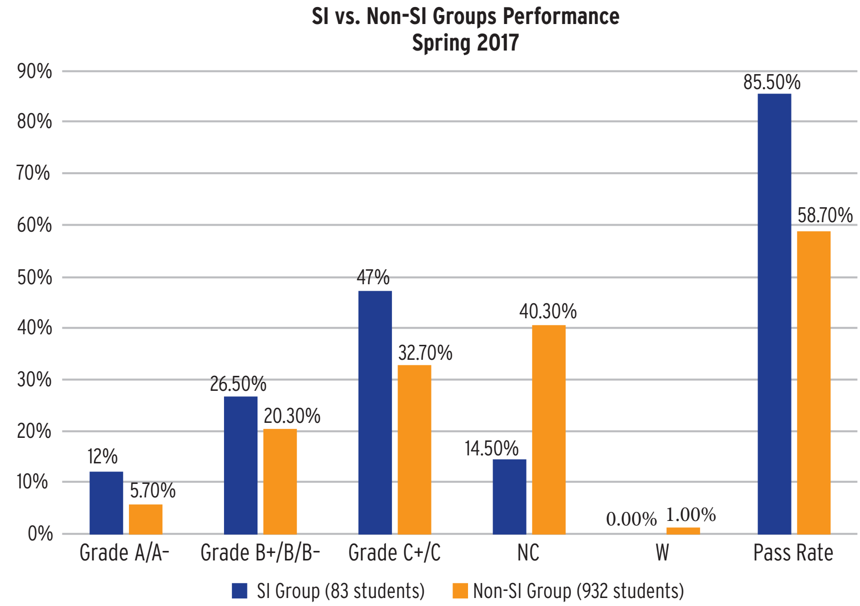
At Cal State LA, about 52% of entering freshmen are underprepared for college-level math coursework. They come from under-resourced urban high schools, where 64% are PELL eligible (low-income families), and 45% first-generation. All of the national data reporting those characteristics indicate these students are "at-risk" for academic failure. First-year math has historically become an insurmountable barrier for many of them. The pass rate that was around 60% clearly indicated a dire need for improvement.

Cal State LA *Smart Start* is a program designed to provide academic support for first-year students. To help those struggling with math, Suzanne McEvoy implemented the Supplemental Instruction (SI) for Math 930 (Intermediate Algebra), the pre-collegiate course known to be the main gatekeeper for these students from taking the college-level General Education Math. SI is an academic support program, initially introduced by the University of Missouri Kansas City (UMKC), that focuses on collaboration, group study, and interaction for assisting students in understanding and navigating traditionally difficult courses. The SI model we developed was a modified version of the UMKC SI model.

Photo: An SI student explaining the result of her group work to an SI leader.

Innovations to the UMKC Model

In the UMKC model, several SI sessions are offered weekly and students from any section can voluntarily participate. We quickly learned that this could not be coordinated very well and attendance was poor on our campus. We then decided to add individual SI sessions meeting twice a week immediately after the lecture to several sections of Math 930.



Since there were only a few sections of Math 930 with SI support, we needed to specifically target the students with the greatest need of this extra support. In coordination with the math department, *Smart Start* identified the students who had failed this class at least once and placed these students in Math 930 with SI support. Unlike the UMKC SI model, attendance in our SI session is mandatory for these at-risk students.

It is no secret to us that students struggling in math tend to avoid math in the first place. The SI sessions address this issue by creating a comfortable active learning environment for the students. Each session is facilitated by one or two peer SI leaders who are trained and supervised by the SI Coordinator. One typical activity during an SI session is as follows: students are divided into small groups of three or four working on problems, while the SI leaders walk around checking the progress of each group.

The types of questions that students work on during an SI session are varied in the level of complexity. During the first 20–25 minutes students work on straightforward problems, such as:

Factor $64x^3y - 81xy^3$; *Solve* $\sqrt{2x-3} = 3 - x$.

These problems serve as review questions. To get the students motivated and ready to work in groups, SI leaders use such problems as questions for fast-paced games, e.g., Tic-Tac-Toe or Jeopardy. In the next 35–40 minutes, students work on more complex problems which often involved applications. For example:

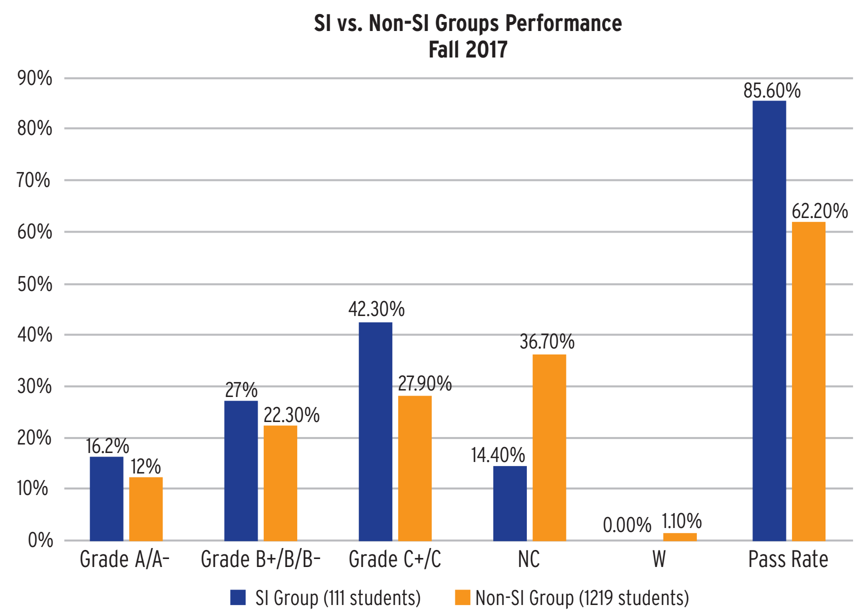
Adam and Bob own a painting company. Adam can complete the painting work of an office in 3 hours, while Bob takes 4 hours to complete the same job. If both of them work together, how long will it take to paint the office?

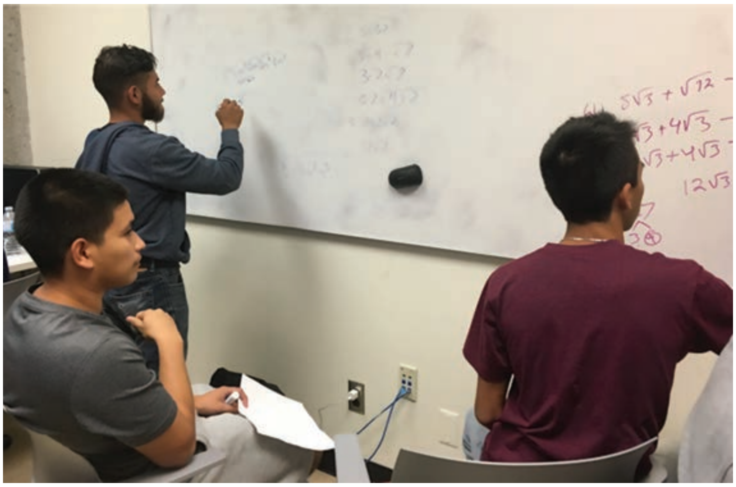
A rectangular garden has a width that is 4 meters less than the length. If the area of the garden is 140 square meters, find the width of the garden.

Students tend to avoid word problems. Many of them do not know how to start as there is no equation provided by the problem. Techniques such as think-pair-share or group discussion are often employed to help students formulate the needed equation. The SI leaders are not tutors or instructors who provide solutions or yes/no answers. Instead, these leaders encourage collaboration and discussion among group members to arrive at the correct solution and better understanding of the concepts and materials. In addition to problem solving, SI leaders also help students develop good study habits and become independent learners. This is important as these students will have to survive on their own when they take their next math class.

Results

The results from our SI are quite encouraging. We witnessed that the students' attitude towards math changed over the semester. In addition to attending the mandatory SI sessions, a good number of students also voluntarily attended the SI extended hours to work more on math problems. The bar





SI students taking an active role in working on problems on the board while monitored by an SI leader.

graphs shown compare the performance of SI and non-SI students over two semesters since the model was implemented. Higher percentages of SI students earned the passing grades of A, B, or C, and fewer of them failed (NC) or withdrew (W). The overall pass rates were around 85% for both semesters, while the non-SI group's pass rates were only 58% and 62% in spring and fall 2017, respectively.

Given the success we had, *Smart Start* was asked to run a 17-day Winter Intersession Boot Camp for students who did not pass Math 930 in fall 2017. With such a short duration to cover one entire semester of materials, *Smart Start* made some model adjustments. In addition to carefully coordinating the lecture and SI, we decided to augment the one-hour SI session with an additional hour of the Emporium model, where students worked with an online adaptive learning platform called EdReady. Both SI and EdReady sessions were facilitated by SI leaders. The median score on the EdReady diagnostic test improved from 44 (pre-test) to 87 (post-test), indicating students learning increased during those 17 days. The overall pass rate for this Boot Camp was 65%, which was quite comparable to Math 930 course instruction during regular semesters.

We are currently tracking these SI students to see how they perform in their next math course and further analyze the effectiveness of SI. In the meantime, we hope our results can generate a few ideas for readers who are interested in implementing SI for at-risk students in a regular class or in a Math Boot Camp. ■

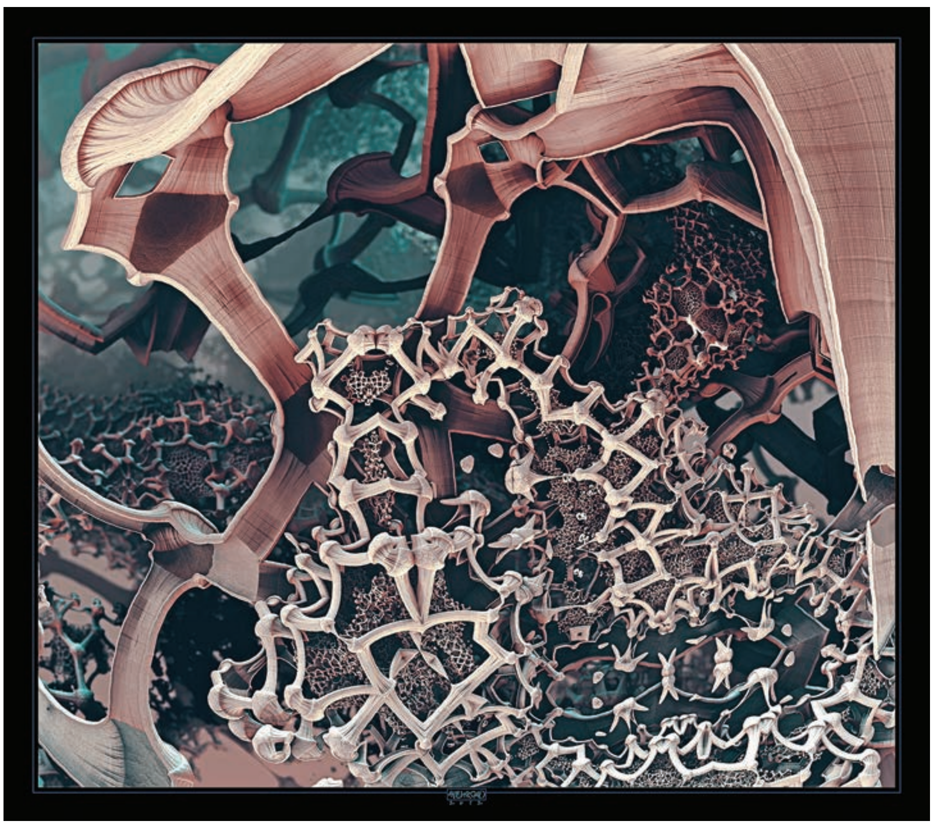
Melisa Hendrata is an Associate Professor of Mathematics and SI Coordinator for Smart Start at CSU Los Angeles. Suzanne McEvoy is the Director of Smart Start for Student Success at CSU Los Angeles.

Martian Sperm

Fractal Art

Mehrdad Garousi has been a fractal artist for more than ten years. Having experimented with different media he chose digital fractal making as the best medium capable of fulfilling simultaneously his scientific and artistic concerns and expectations. He uses fractal art as a medium to create and explore other-worldly psychedelic landscapes from other dimensions and represent them as art (still images and animations). His art is a combination of fractal mathematics, psychedelia, bizarre forms, alien aesthetics, and a huge amount of details. One of his concerns as a fractal artist has been to push this new-born science-art area from absolutely abstract and theme-less works to those with more accessible themes. For example a set of his fractals represent biologic forms. In fact these works use the art derived from nature to create natural forms and phenomena. They display a cyclic relationship among nature, science, technology, and art and show how the science and technology derived from nature can lead to the study of nature again: fractal mathematics is based on nature's behavior, fractal images are created by means of the technology of computers, and in the end these digital fractals are used to create natural forms of life through artistic processes. Creating a nature-science-technology-art-nature cycle. ■

Mehrdad Garousi can be contacted at mehrdad_fractal@yahoo.com. *See more of his art at* mehrdadart.deviantart.com/.



Within the Pineal Gland

A Wake-up Moment

An Exercise in Actually Practicing What One Preaches about Mathematics

James Tanton

I recently publicly accused myself of being a hypocrite. (See *James Tanton is a Hypocrite (and I am James Tanton, by the way),* bit.ly/2JNBuBU.)

For the past year, as co-founder of The Global Math Project (theglobalmathproject.org), I have invited—cajoled perhaps—thousands of educators across the planet to introduce to their middle-school, high-school, or college-level students a joyous, uplifting, piece of curriculum-relevant mathematics: the story of Exploding Dots (explodingdots.org). And the enterprise has been an astounding success! At the time of writing this article, 4.6 million students from over 160 countries and territories have engaged with our material, including students in New York City using our high-technology web app and students in Zimbabwe discovering binary numbers using pebbles and hand-holes dug into the school yard ground. All has been grassroots. All has been volunteer. All has been based simply on our fabulous global community of teachers and their students believing in mathematics and setting it free to simply shine for its own glorious self. Millions of students let go of their trepidations and emotional woes and tried an "unusual" stance to school-room math. And they shared their experiences on social media.

And then I recently caught myself being a hypocrite.

I was talking to the PR representative of a professional sports team about a possible collaboration and observed myself saying the following during that call:

"I am not a sports person."

"I never liked sports in school and avoided them whenever I could."

"I am just not good at sports."

First, what I was saying was simply rude, especially to someone whose career is about promoting the joys of sports to hundreds of thousands of people! And second, change the subject of those sentences to "math" and I would be saying the very things I lament that the world so readily pro-

nounces about doing mathematics! If I am truly working to change the world's perception of what engaging in mathematics can be, then I simply cannot engage in the same lamentable mindset about sports, or any topic of human endeavor. I apologized for my unprocessed mindset during the call and set to simply get-over it.

Then came an email from the Orlando Math Circle (orlandomathcircle.org) director, Margarita Azbel, who had read my piece of self-realization and challenged me: Do I really mean to get over it? She had reached out to the NBA's Orlando Magic who were indeed set to have their ambassador, retired player Bo Outlaw, come out to teach me basketball in exchange for me teaching him some mathematics. I had to say "yes." So in May, totally terrified (truly, I have never played basketball, never dribbled a ball even) I flew to Orlando and met Bo and his film crew team for a basketball/math exchange.

We decided that Orlando Math Circle students would be involved, too, and all was set for a chaotic hour in a school gym (thank you Lake Highland Preparatory School), with about 35 students (and about 20 adults looking on), and cameras and white boards and basketballs. The MAA had provided me a fabulous jersey, which I proudly wore. (My number on the jersey is 10,000,000, the count of students we hope to reach for Global Math Week starting 10.10.2018.)

Bo started me and the kids on some defense exercises (a lot of sideways skipping was involved) and then we moved on to "layups." I am not really sure what they are, but they involved me attempting to dribble the ball and take a shot when it came to my turn. All cameras were on me—yeesh—and I said to Bo as I went past him, "I've never dribbled a ball before." He said, "I can tell," and gave me a huge high-five for trying. (Nerves really were at the fore.)

Then over to the whiteboard. Bo gave me a lesson on basketball plays as all the kids watched. I really didn't have a clue what he was talking about. I also didn't understand the picture he drew on the board—a rectangle with a semi-circle. I knew this was some part the court, but I couldn't look over at that moment to try to figure out which end of the picture the hoop is. Anyway, I did follow along enough to take in the remarkable body intuition players have for motion, anticipation of motions, and the necessary

So now I have to ask: What is the topic or activity that is out of your box? Might you be up for a new activity/math exchange of some kind too? Can we develop a repository of such stories and videos for students of all ages to view and admire? What a powerful message we could together send to the world, that life really is about being fully open, and vulnerable, to living and learning.

We mathematicians can lead a path. Let's do it! ■

quick-time response to all those motions. It truly is remarkable, and very spatially mathematical.

Next, I changed into my "mathematician's clothes," as the film crew called them, and it was my turn to give Bo a math lesson.

I started with Bo and the kids doing the International Math Salute, of course! (Google it.) And Bo was quick: he figured it out on his second try and was rightly pleased with himself. And then I think he realized I wasn't going to do the typical math he expected. (He was joking with the kids earlier about doing multiplication computations.)

I then started the story of Exploding Dots, swiftly going through a base-two machine and then on to a base-10 machine. (I was told I had seven minutes!) Bo and the students enjoyed the "aha" moment that 273 really is two-HUNDRED, seven-TY, three. We then talked about base-20 in human culture and Bo figured out that fingers and toes must have been the motivation. He was chuffed with the idea that Abraham Lincoln's start to the Gettysburg address is a vestige of base 20. We also talked about base 12 possibly coming from counting on one hand as is done in many South East Asian cultures, before returning to the base-two machine to really clinch the mathematics behind it. Bo then worked out, on the white board in front of the kids, what ten is in base-two. He was mighty pleased.

And then the film crew packed up and left before I knew it, before I had the chance to say good-bye even. They were clearly on a schedule.

This experience was wild and so very much out of my "math norm" box. And I loved it. And I particularly love the message we came up with for this sports/math exchange:

Open your mind to sports. Open your mind to math.
Open your mind to learning and living fully.

You can see the video of the event, put together by the Orlando Magic film team, at bit.ly/2K3XYhx.

Learn Math and Live Longer

An interview with Dr. Ellen Peters

Michael Pearson

Those of us who teach mathematics believe that the critical thinking skills gained through proficiency in mathematics has value that extends across multiple areas of our students' lives. Research in cognitive science is beginning to provide some striking evidence that we are right.

The Decision Sciences Collaborative at The Ohio State University brings together researchers from diverse fields to develop basic theory in decision making and uses it to help people improve their decisions and, ultimately, their well-being.

I recently spoke to the Director of the Collaborative, Dr. Ellen Peters, to learn more about her work. In her research, Dr. Peters focuses on understanding the basic building blocks of human judgment and decision making. In recent publications, Dr. Peters and colleagues have focused on how numeric and non-numeric information are processed in decisions by individuals who differ in number ability (also called numeracy). She is also generally interested in issues of risk perception and risk communication in health, financial, and environmental contexts, including how to present information to facilitate its comprehension and use.

Michael Pearson: What were your early experiences that led to your interest in numeracy, or as we in the MAA often frame it, quantitative literacy, as an element in decision-making?

I was originally an engineer and loved math and mathematical modeling in classes. Although I ultimately chose psychology and the study of decision-making as a career path, numbers are really important to decisions that we make in life about our health, our finances, even our sports. As I studied the psychology, people's understanding (and, oftentimes, lack of understanding) of numbers kept popping up as key to how they judged risks and made decisions. For example, why should someone find a cancer treatment more appealing when it's described as having a 92% survival rate than an 8% mortality rate? That made no sense to me; they're the same number, but I realized that not everybody transformed the number from the first format to the second (92% survival = 8% mortality). I started getting interested in how differences in people's numeric abilities impact how they process numeric information in decisions.

The highly numerate work more with, and think more about, numbers in decisions, presumably because they can; they "have a hammer" and therefore they use it.

MP: Your research has surfaced interesting connections between numeracy and effective decision-making. What's your "elevator speech" version of the key insights you and your colleagues have made?

To make good informed decisions, you first have to understand the information, and, of course, people who have fewer math skills understand less of the numeric information important to choices. But numeracy affects much more than simple comprehension. It concerns how and how much we think and reason with numbers. For example, people who have gaps in numeracy rely on concrete, easy-to-evaluate attributes when they judge and decide. They neglect base rates, denominators and other statistics that often are logically better sources of information, relying instead on concrete descriptions, narratives, and emotional reactions. The highly numerate, on the other hand, do more careful analysis. It's not that they don't use provided narrative information or their own emotional reactions, but they use more and more complex information. They attend to and search more for numbers. They also work more with, and think more about, numbers in decisions, presumably because they can; they "have a hammer" and therefore they use it. In a series of studies in our lab and other labs, we find that the same information exerts a different influence on judgments and decisions depending on the person's level of numeracy. For the less numerate, misunderstanding one piece of information or making a less than careful decision once generally doesn't matter. But doing so repeatedly over time may cause an accumulation of risks that ultimately undermines them.

MP: In your work, you have particular ways to measure numeracy. Can you characterize what numeracy means? In what ways do, or can, mathematics courses contribute to our students' numeracy?

We define objective numeracy as the ability to comprehend and use probabilistic and other mathematical concepts. We often measure it with probabilistic items. For example, "Which of the following numbers represents the biggest risk of getting a disease? 1%, 10%, or 5%;" in a recent U.S. representative sample, 17% of adults answered even this very simple problem incorrectly. We have also measured numeracy, however, with arithmetic problems, for example, in a sample of rural Ghanaian adults who did not recognize probabilities. We have shown similar effects of these different kinds of numeracy items on decision problems. Based on our research so far, I do not think that particular types of math ability matter to decisions more than others (e.g., statistics, arithmetic, algebra), but I am open to being proven wrong. Instead, it seems important to have a measure that spans an appropriate range of difficulty for the population that I'm studying (easier measures for Ghanaian adults with no formal education; harder measures for business school students). So long as the appropriate difficulty level is chosen for the population I'm studying, I believe I can use arithmetic, algebra, or probabilistic items, and they should predict judgments and decisions similarly. Math courses are at the heart of this process, teaching students to pick up ever-heavier boulders of mathematical knowledge that enable them to think and reason more effectively in their own lives.

MP: What are some of the decision-making situations you've examined in your research?

We have looked at a variety of situations in the lab. For example, numeracy has implications for how we communicate

medical risks. In one study we did, a medication decreased the number and severity of headaches, but it had one possible side effect, a bad blistering rash that covered the body. Half of the people in the study were told that 10% of patients got the rash; the other half were told that 10 out of every 100 patients got the rash. People who were good at math perceived the risk similarly in both cases. However, less numerate people perceived more risk in the frequency format (10 out of every 100 patients) than the percentage format (10%) and were less likely to take the medication.

In the frequency format, we think that less numerate people imagined people with the rash and reacted emotionally whereas in the percentage format, they perceived the risk as abstract, just a small number. Among the highly numerate, we think they transformed the number (e.g., from 10% to 10 out of 100 and vice versa) and perceived the risk similarly as a result. Some research suggests that the 10 out of 100 would be perceived as riskier than 1 out of 10 (there are 9 more people). Yamagishi (1997), for example, found that participants rated cancer as riskier when it was described as 'kills 1,286 out of 10,000 people' than as 'kills 24.14 out of 100 people.'

We have also found that more numerate individuals in the highlands of Peru are more likely to use condoms to protect against HIV. More numerate Americans are more financially literate, and they also have better financial outcomes, including being more likely to avoid predatory loans, save for retirement, and pay loans on time and in full.

And it's not simply that the more numerate are smarter. In each of these studies, we also controlled for other measures of general intelligence. In addition, we have experimentally increased college students' numeracy and shown causal effects on financial literacy and health behaviors. We need much more of this experimental research, however.

MP: You've also done some work on how to adjust classroom environments in statistics courses to improve student perseverance and success. What advice can you give those of us who teach mathematics that might improve the learning outcomes for our students?

The concept of numeric self-efficacy is really important to persistence in learning and decisions involving numbers. It's also related to the common finding that students are anxious about math and math classes. We've been testing different ways that instructors can provide cues to improve this efficacy and increase persistence with numbers. In one study, for example, we used a psychological intervention, called "values affirmation," to help students cope and learn more in a tough statistics course.

In the study, students first completed the values affirmation exercise near the beginning of the course. They were given a list of six values (including relationships with family and friends, spiritual/religious values and science/pursuit of knowledge) and asked to rank them in importance to themselves personally. Half the students affirmed their values by spending 10 to 15 minutes writing why their most important value was meaningful to them. The other half of the students, the study's control group, took their least important value and wrote about why it might be meaningful for someone else. The students repeated the exercise a second time right before their first exam.

> "How we make decisions about our health, finances and environment will determine our welfare today and into tomorrow." —Ellen Peters

We then tested whether the intervention helped students feel better about their numeric ability (their so-called subjective numeracy in response to questions such as "How good are you at working with fractions?") and whether it helped improve their objective numeracy (their scores on a math test we gave them). The intervention protected their subjective sense of their own numeracy (students in the control condition felt worse about their numeric abilities by the end of the semester). The intervention also improved their objective numeracy. These changes were reflected in their critical thinking skills in that students in the intervention condition completed the course with better financial literacy and healthier behaviors.

We are very interested in replicating and extending this study, using this and other methods to improve numeric self-efficacy and objective numeracy. ■

Michael Pearson is Executive Director of the Mathematical Association of America.

GET MORE

Dr. Peters will be at the MAA Carriage House on Tuesday, October 16, as part of the MAA Distinguished Lecture Series.

Building Pythonic Pyramids in Nigeria

Christopher Thron

The International Mathematicians' Union (IMU) began its Visiting Lecturer Program (VLP) in 2008, inspired by similar programs from the Centre International de Mathématiques Pures et Appliquées (CIMPA); London Mathematical Society; and Norwegian Program for Development, Research and Education. In ten years the VLP has supported lecturers' visits to seventeen different countries in Africa, Central America, the Middle East, and Southeast Asia. Lecturers offer intensive 3–4 week courses that are part of a regular undergraduate or Master's degree program (see bit.ly/2qF8ccs for more information).

The First Iteration

Photo above: Post exam group photo
Right: Thron with professors Bamigbola (course facilitator and host) and Adeniyi (head of department)

In Spring 2016, the VLP supported a "Mathematical Software" course which I delivered to second-year students at the University of Ilorin, Nigeria. Materials were adapted (with permission) from the University of Edinburgh's "Interactive Introduction to MATLAB" course (MATLAB.eng.ed.ac.uk/): these included a PDF textbook and YouTube videos (see bit.ly/2J57zk2). Knowing that pirated software is common in Nigeria (and other African countries), I taught the course using Octave (gnu.org/software/octave/), an open-source software that can run generic MATLAB programs without any modification. Only a few students (maybe 20 percent) had their own laptops or access to computers outside of class, so I resorted to an active learning approach, where the bulk of class time was occupied with hands-on activities. Between the desktops in the lab and students' personal laptops, we ended up with about 3–4 students per computer.

The course was a mixed success. Some students got in lots of programming practice, but many others watched passively. Students often got stuck on the in-class exercises, and would wait for me to come around to their group and help out—but since there were close to 20 different groups, this meant that progress was slow. The final exam scores had a rather low mean and huge standard deviation.

The Second Iteration

In 2017, the IMU approved my application to return to the University of Ilorin to offer a similar course. I was determined to address some of the previous deficiencies. First was the choice of software. Over the previous few months I had become increasingly aware of the relative benefits of Python, which holds the #1 spot on the 2017 IEEE list of programming languages (bit.ly/2wWgUaB), reflecting Python's widespread use across disciplinary boundaries. Students that do not become mathematicians should be equipped with technical skills that are useful outside of mathematics (and especially in data science). Python is only slightly more difficult to learn than MATLAB/Octave—for example there are some idiosyncrasies with variable types, which are handled automatically by MATLAB. All features and packages necessary for a course in mathematical programming are included within Anaconda (bit.ly/2JVHQMc), a free Python distribution that is available in Windows, Mac, and Linux.

I wanted to keep the active learning format, but to get the course moving at a reasonable pace, I would have to do something about the "stuck students" issue. The best way would be to get class helpers. Inspired by pyramid sales schemes, I envisioned a "Pythonic pyramid": train a small group of advanced students in Python so they could effectively share their knowledge with other students with the hope that this knowledge sharing could become a chain reaction, producing a larger and larger base of Python users. I tried get the pyramid started by running a workshop for selected graduate students who would then help out with my undergraduate class.

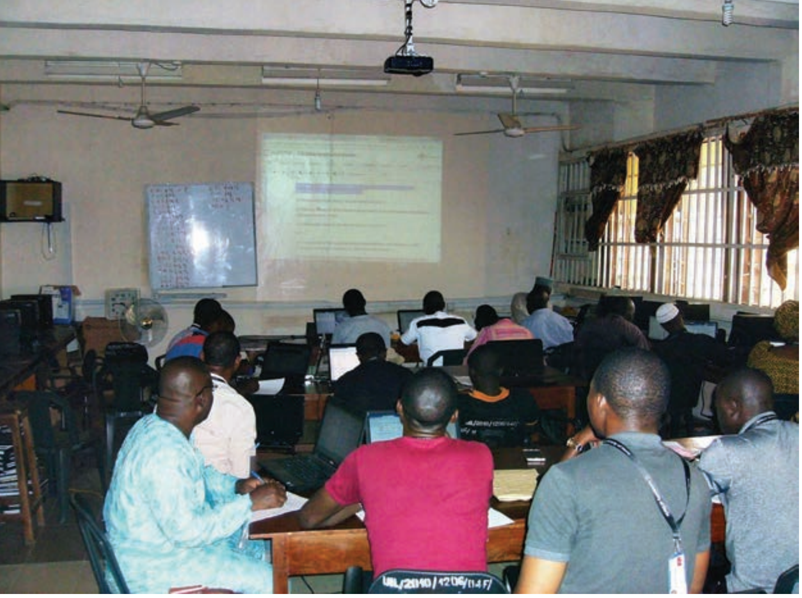
With only three months to develop my curriculum, I adapted Hans Fangohr's online Python resource (bit.ly/2LalzgV), which had material in a variety of formats including Jupyter notebook. Although the list of topics was good, I ended up completely rewriting and reorganizing the material for my own target audience to cover at least one mathematical application. For this, I used a chapter by Brian Storey on numerical solution of ODEs (bit.ly/2HtAiBH) that is organized around successively more sophisticated MATLAB programs. My final list of topics was:

- Python user interface (Anaconda and Jupyter)
- Algebraic and mathematical operations
- Data types (integer, real, complex) and structures (string, list, tuple)
- Arrays: vectors, and matrices with numpy (Python's numerical math package)
- Visualizing data (plotting) using matplotlib (Python's MATLAB-clone plotting package)
- Control flow (loops and conditional statements)
- Functions
- Application: Numerical solution of differential equations

The hands-on approach which I planned demanded that I provide numerous exercises for the students. Fangohr had labs for his students in addition to class material, but I had only three weeks (and three different sections), so any student programming would have to take place during class time. Designing suitable exercises was a challenging task. If the exercises were too easy, students wouldn't be challenged to think—but if they were too hard, students would sit idle until an instructor came to assist them. Some students were much slower than others, so for each topic I put together a minimal set of exercises to establish basic competency, as well as further exercises for faster students who would otherwise be idle while the rest of the class finished.

Building the Pyramid

I arrived in Ilorin two days before my graduate seminar was scheduled to begin. The next day was occupied with arranging the schedule and setting up the lab. The lab computers were not networked and had no internet connection, so software was installed by flash drive. This created two main problems. First, my flash drives didn't always get back to me when I loaned them to students to install Anaconda on their personal computers. Second, and more seriously, many



computers in Africa are infected with a pernicious "shortcut" virus that spreads via USB. This virus (which I'd never encountered in the US) is pervasive in west central Africa, probably because so much software is shared via USB. Out of five student laptops, chances are that at least one is infected with the virus. Fortunately, there is a free program called Smadav (www.smadav.net/?lang=en) which provides effective protection—but even Smadav is unable to clean a computer that is already infected.

Besides logistical issues, there were pedagogical challenges as well. My past experience showed that many Nigerian students (not too unlike American students) are content to sit through classes without absorbing anything, then cram furiously before the exam. I had to come up with some strong motivation for students to keep up with and actively participate in the class. I also had to combat a generally lackadaisical attitude towards attendance, and especially towards punctuality—I'd found previously that it was not unusual for the class to start out almost empty, and have students trickle in gradually during the class period. To deal with this, I started each class session with a short 2- or 3-question quiz of about 10 minutes.

The preliminary workshop with graduate students went well with about 30 participants, three times the number that I originally envisioned. Interest level and motivation was high, and the students responded well to personal interactions during periods of hands-on activity. The biggest problem seemed to be that quizzes were too hard, although they were very closely modeled on exercises that students had previously done. It seems there just wasn't enough time for the material to sink in.

The Implementation

The undergraduate class began the following Monday. The original roster had about 90 students, although attendance at first was somewhat less than this, and by the end of the course the number enrolled surpassed 100. Students were divided into three sections, and each section came two days a week for two 3-hour sessions (morning and afternoon).

Lectures consisted of my showing the Jupyter notebooks on the screen, with code cell outputs removed, revealing the code cell-by-cell, and then showing the output. I was fairly successful at keeping direct presentations at 15 minutes, then having students work on exercises to reinforce their familiarity with features I had just introduced. Acoustics were bad, and the air conditioner was loud, so I had to insist on no talking whatsoever when I was talking (at times I felt like a drill sergeant). I also had to consciously resist my lazy American tendency to blur syllables together. By referring constantly to the material displayed on the screen, it seems I was able to achieve fairly efficient information transfer.

Usually three or four students worked together on a single computer. For the most part, exercises were solved through collaborative effort. Free discussion among students was facilitated by the fact that they had already taken several classes together. As the course progressed, I was encouraged to see students going around to look at other groups' progress, rather than waiting for me to come around to help. Some groups sailed through the exercises on their own, while others needed help at virtually every step. I circulated constantly as they worked, and explained error messages to the students so that they would be able to diagnose errors for themselves. I also emphasized that students needed to think like the computer, and follow the program line by line—this was quite difficult for many students, particularly those who were new to computers.

Adding to the excitement was the perpetual threat of power failure. Fortunately, the projector and lab computers were connected to UPS, so outages didn't cause an immediate standstill. The mathematics department had a (rather noisy) generator, but it was not working for most of the duration of my stay. I had also brought a portable projector with a battery that was good for about an hour. In the end, I only had to cancel part of one class due to power problems.

Results

Unfortunately, the "pyramid" I had envisioned did not quite materialize. Graduate students were scheduled to assist me in each undergraduate class session, but often no one showed up. Those that did show up didn't always take the task seriously, either talking among themselves, or leaving after a short time. It would have been better if the graduate seminar were smaller and consisted only of students that were committed to building the pyramid. Those times that graduate students came and persisted, I took pains to explain the exercises thoroughly so that they could circulate and provide effective help. I am hopeful that their positive experiences will prepare the ground for future pyramid construction.

As planned, short quizzes were administered at the beginning of each session. Participation in the first quiz was about 40 percent, but reached over 70 percent by the end of the course.

Since I wanted to highlight the mathematical capabilities of Python, many of the quiz questions involved basic trigonometry, complex numbers, modular arithmetic, and so on. Many students seemed unaware of basic mathematical facts such as the relationship between trigonometric functions and the unit circle. The departmental faculty told me that indeed students were having trouble retaining material from earlier classes (not unlike the situation in my home institution). This may be due to poor preparation in the lower grades—students' technical skills in algebra are poor, so they are still struggling with algebra while they should be focusing on new concepts.

Altogether about 10 undergraduate students (besides 20 or so graduate students) installed Anaconda on their own laptops. One student put Python on his Android tablet, but was unable to install the 'numpy' module which enables vector and matrix operations. If an easy installation of Python with 'numpy' and 'matplotlib' (plotting routines) were made available for Android, Python could reach a far wider audience among African students since there are online Python servers that can be accessed via Android, but extensive internet use is too expensive for many students.

All instructional materials (including examples, exercises, and in-class quizzes) were uploaded to the class' Whatsapp group in PDF and Jupyter notebook format. One day was dedicated for review—three review sessions were held, and were well attended. Scores on the final examination ranged from 4 to 100.

In all, the seminar and course went a long way towards increasing awareness of Python among students and faculty, which had been virtually nil before I arrived. The collaborative learning approach took positive advantage of Nigerian students' lively social dynamics, and enabled close personal interaction between instructor and students. As a result, I was able to get a much clearer idea of students' progress, and to address their misunderstandings directly. I also had many opportunities to talk with students about their opinions and aspirations (besides appearing in dozens of Facebook selfies). I have even maintained email contact with some students. Although no course evaluations were distributed for students to share their feedback, some students have expressed their appreciation of my methods. One student emailed me saying "It was one of the best experiences I've had."

Several general areas for improvement also became evident. The Pythonic pyramid did not reach the second floor: no local instructors were sufficiently equipped to teach a Python class on their own. The graduate seminar contained too many students who lacked either the interest or the capability

of passing their knowledge on to others. If the pyramid is to gain significant altitude, intensive mentoring should be provided to a handful of instructors who see the value of Python and are willing to commit both to learn and "evangelize" for themselves.

Students need regular access to computing devices that can run Python and preferably devices they own themselves. Python is not too resource-intensive, so if old second-hand laptops were made available to students at low cost it could have a big positive impact. The University of Ilorin has a program for distributing Android tablets to students (bit.ly/2qESPAE); but as mentioned above, there is no straightforward procedure for installing Python on Android with the necessary modules. The problem could also be solved with fast, universal internet (or intranet) access on campus, through which students could access Python servers on their tablets or even smart phones.

In today's world, a mathematically and computationally savvy workforce is a necessary prerequisite for a competitive national economy. Programs like this one can improve students' deficient experience with computers, improve their attitudes towards academics, closing the technology gap between Nigeria and more advanced countries. I am hopeful that persistent pyramid-building efforts may eventually pay off, and students may catch a vision for the possibilities of Python (and mathematical programming in general) to bring Nigeria to new levels of development. ■

Christopher Thron is associate professor and chair of the Department of Science and Mathematics at Texas A&M University-Central Texas. He has taught courses and workshops in mathematics, statistics, and software in Cameroon, Chad, Nigeria, Sudan, and the People's Republic of China.

Departments

PRESIDENT'S MESSAGE

Soaring into a New Year

—Deanna Haunsperger

It's summer, but my thoughts have already begun to turn to my classes for this next academic year. When I read the Instructional Practices Guide this past winter, I really appreciated the thoughtful recommendations, complete with vignettes to show how the ideas might play out in a classroom like mine. The recommendations aren't the result of folks sitting around a table, kvetching about their students and throwing out their personal preferences; these best practices are based on educational research, and the references themselves make for interesting reading.

Thinking about my classes got me wondering what the best mathematics professors do to prepare for the coming year. So I asked them. The most prestigious award for undergraduate teaching given by the MAA is the Deborah and Franklin Tepper Haimo Award. I interviewed Haimo award winners from the past six years to find out what they were thinking about in preparation for their next classes. Two facets of their responses immediately grabbed my attention: no one I asked thought this was a silly question—everyone was already planning for fall (and winter) term classes. And not a single person was resting on his or her laurels (and these people actually have laurels on which to rest). Many folks had requested something different to teach so that they could experiment or test a new idea or a new experience in teaching.

Glen Van Brummelen is giving a teaching workshop to the faculty at Habib University in Pakistan, and has been consciously considering the narrative arc of both the course and the individual topics within the class. "If students can be made to feel the need for a solution and participate in the narrative, I think they'll take a lot more ownership."

Tevian Dray has taught non-euclidean geometry many times before, but this year he's planning to embed GeoGebra into the course's website. "Users will need nothing more than a modern browser to interact with these materials, which in the long run are intended to bring active engagement to open-access online textbooks."

"What is the best way to use color in teaching math proof methods and logic arguments?" is what **Satyan Devadoss** is thinking about for the fall.

Gary Gordon will be continuing his bi-weekly "Teaching Lunch," where the mathematics department buys lunch and faculty get to talk about topics of interest (such as "battles not worth fighting" and "with student access to technology, are take-home tests a thing of the past?").

Hortensia Soto has been working on transforming her students' mindset by having them say little positive affirmations before an exam to help calm them down. She's also trying to be more conscientious of "privilege of time" which many students may not have if they have to work full-time while being a student.

Matthias Beck is looking forward to teaching optimization because he's never taught it and elementary number theory because he's completely revamping his approach to an "extreme IBL" style.

"The world of mathematics is very different from what it was [when I started teaching]. There is so much new mathematics and so many new applications and uses of mathematics, it isn't fair to students to leave out all the exciting new stuff just because 'we have always done it like this.'" **Tyler Jarvis** is focused on where math is going, what his students need, and the best ways to get them where they need to be.

Francis Su was encouraged by his colleague Darryl Yong to avoid assigning routine problems in group settings, but to create "group-worthy" tasks where having multiple people is really better than just one. "That avoids the problem of one student dominating because she's faster than everyone else, and helps everyone see the benefits of having lots of minds working on aspects of a rich, complex problem."

In **Margaret Robinson**'s discrete math course last spring, she had her students prepare a "written portfolio involving some LaTeX'ed problems selected from homework." Students met with her individually at the end of the term for an oral defense of their portfolios. Margaret plans to use this confidence-building approach again this fall.

Retirement is not slowing down **Janet Barnett**, who is continuing curriculum development work with Primary Source Projects. Through this work Janet learns new approaches to mathematical concepts and new ways to engage students in thinking about them.

Ron Taylor is excited about his upcoming calculus class of all first-year students; he read the book *Hacking Homework* so that he can make their homework assignments more meaningful for them, including incorporating more self-reflections about their thinking process.

Andrew Bennett wanted a new environment from his more-than-thirty-years of face-to-face classes, so he taught online classes last year; he's ready to incorporate what he learned in the next generation of these courses.

Judith Covington is changing jobs after 25 years, giving herself an opportunity to teach a new group of students and a different set of courses.

Brian Hopkins gave students the opportunity to see how "researchers communicate in volleys of articles to develop mathematical ideas" by creating a thread of research journal articles for students to work through as part of a senior capstone course.

Gavin LaRose will be teaching two classes in a large-lecture (100–120 person) format, and he'd like to push further than he got last time in his effort to have students develop a greater part of their own understanding through their own work. This is complicated by the number of students in the room, but he's going for it.

I don't have new classes to teach this year, but I am excited that I was assigned to mentor one of my new colleagues who will start this fall. This gives me an opportunity to discuss pedagogy and classroom teaching ideas from first principles. We can read the Instructional Practices Guide together. We can visit each other's classes—I bring experience and she brings fresh ideas. We can work together on issues of inclusion and community, both in our classes and in our department.

A former colleague of mine always said that the second-best day of the school year was the last day of classes in the spring. But the best day—the one that holds so much promise and excitement and joy—is the first day of classes in the fall. The slate is wiped clean (literally) for you and your students, you get the privilege of setting the expectations and the tone for the class and potentially the year, and the world is filled with possibility and wonder. ■

Deanna Haunsperger is MAA president and professor of mathematics at Carleton College (email: dhaunspe@carleton.edu*).*

Departments

PUZZLE PAGE

Knights and Bishops

—David Nacin

Fill in the cells with Knights and Bishops so that every row and column contains the same number of each. The numeric clues indicate the number of pieces of the same type that the piece in that cell can attack. Assume that pieces do not block attacks when computing this number for bishops. For example, a clue of 5 in a cell indicates that there is a either knight in that cell that can attack five other knights, or a bishop in that cell that can attack five other bishops. ■

David Nacin is a professor at William Paterson University. He enjoys designing and studying puzzles that involve groups and Lie algebras, partition identities, the motion of chess pieces, and other mathematical structures. He maintains a free puzzle blog at quadratablog.blogspot.com.

Sample solved 4 by 4 puzzle

Easy

2	2	1	2
1	3	2	2
2	3	3	2
1	1	3	2

Hard

4	1	5	1	3	4	3	1
1	6	1	5	3	5	1	2
4	4	5	3	5	3	4	2
2	3	5	7	4	4	4	4
1	3	5	6	5	3	5	4
4	4	5	3	5	4	3	5
3	3	1	5	4	5	6	1
3	2	2	2	4	4	2	1

Medium

3	1	2	1	2	2
2	4	2	3	2	4
3	4	4	4	2	2
1	5	5	6	2	1
1	0	5	3	3	1
1	3	3	2	4	1

MEET A MEMBER

Jeanette Shakalli

We have members involved in many MAA programs, SIGMAAs, and professional development opportunities. This column lets us get to know some of our members a little better.

What is your current job and how long have you been there?

I am currently the Executive Assistant to the National Secretary of Science, Technology and Innovation of Panama. I have been working at the National Secretariat of Science, Technology and Innovation of Panama (SENACYT) for five years, first as the Advisor to the National Secretary (for around 1.5 years) and then as the Executive Assistant to the National Secretary (for 3.5 years, more or less).

My main responsibility is to solve (administrative, personnel and all kinds of) problems. I also supervise the work of the different departments, revise all the documents before the National Secretary signs them, analyze the efficiency of our internal processes, advise the National Secretary on the decisions to make, and manage the National Secretary's calendar.

How long have you been an MAA member, and why did you initially join?

I joined the MAA in 2015. At the AMS Dinner at JMM 2015, the AMS President at the time, David Vogan, and the Secretary of the AMS, Carla Savage, recommended I attend MAA MathFest and suggested I join the MAA due to my interests in improving math education in my country and increasing math outreach in Panama. I followed their advice and attended my first MAA MathFest in 2015 and *loved* it!

What has kept you an MAA member since then?

As a mathematician who works for the Panamanian government, I want to inspire our youth to rejoice in the beauty of science and math. Thanks to the MAA, I have learned that there are mathemagicians, mimematicians, standup mathematicians and mathemusicians, that mathematical card tricks exist, and that there are *so* many fascinating ways that we can engage the public to show that math is all around us. For this reason, I started at SENACYT a program in which we invite talented mathematicians to Panama to give a presentation open to the public on a math-related topic that is fun for kids and adults of all ages and that highlights the applications of studying math. I have to admit that seeing the Panamanian audience admiring the beauty of math and sharing my passion for math with them is the most rewarding part of my job, and none of this would have been possible without the MAA.

Describe the MAA in four words.

Community, education, outreach and hope.

What would you like to see from MAA in its second century?

I would like to see more interactions with the MAA international members. It would be interesting if the MAA could have a conference outside of the US. In Panama maybe?

In conclusion, I have found in the MAA a community of professionals who are as passionate for math as I am and it is quite inspiring! As I tell my friends back home, attending my math conferences is necessary for my mental health since it recharges my system and allows me to learn what others are doing, so that I may adapt those ideas to improve math education and increase math outreach in my own country. ■

Departments

MAA BOOKS BEAT

Finding Ellipses

—Stephen Kennedy

It is not very hard to prove that every automorphism of the unit disk in the complex plane is of the form:

$$f(z) = \mu \frac{z-a}{1-\bar{a}z}.$$

Where a is a point inside the disk and μ has norm one. (See, for example, *Complex Analysis* by Bak and Newman.) So, up to an arbitrary rotation, the automorphism is completely determined by which point maps to zero. More is true, any map analytic on an open neighborhood of the closed disk that maps the disk to itself (and the boundary to the boundary) is a finite product of factors of this form. So, tell me the pre-images of zero you want and I can tell you, up to rotation, the unique analytic map with those zeroes that preserves the unit disk. These maps are called *finite Blaschke products*. They have many beautiful properties.

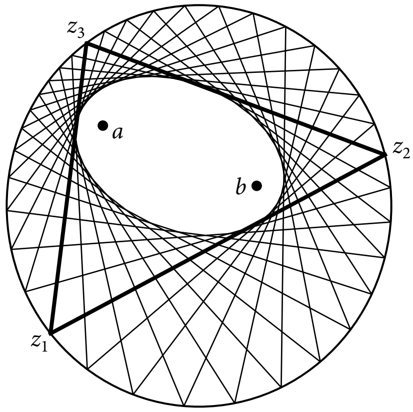
To take one, particularly apposite, example of such a property imagine an arbitrary Blaschke product of degree three, B, with zeroes at 0, a, and b. It is, of course, a three-to-one map of the unit disk to itself. For each point w on the unit circle construct the triangle z_1, z_2, z_3 where $B(z_1) = B(z_2) = B(z_3) = w$. The envelope of this collection of line segments is an ellipse with foci at a and b and common distance $|1-\bar{a}b|$. We'll call this a *Blaschke ellipse*. The very existence of this ellipse should surprise you—at least, it surprised me. Why would those pre-images cooperate so beautifully?

Suppose, to change the subject for a minute, that you have two nondegenerate, nonintersecting conics, C_1 and C_2, in the plane. Suppose further that there exists a triangle with vertices on C_1 all of whose sides are tangent to C_2. Then every point on C_1 is a vertex of such a triangle! This is Poncelet's Theorem. In the case that C_1 is the unit circle we'll call an ellipse that can be an associated C_2 a Poncelet ellipse. One might wonder which ellipses can be Poncelet ellipses.

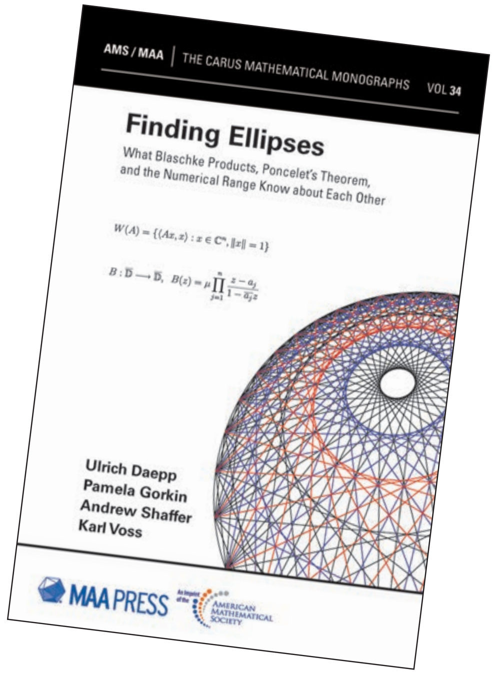
And, in yet another ostensible change of subject, I ask you to consider the numerical range of an $n \times n$ matrix, A, with complex entries. The numerical range of A is defined as:

$$W(A) = \{\langle Ax, x\rangle \mid x \in \mathbb{C}^n, \|x\| = 1\}.$$

First defined by Otto Toeplitz, the numerical range is a generalization, of a sort, of the set of eigenvalues. (The bracket, of course, denotes the inner product.) It should be clear that $W(A)$ contains eigenvalues of A, just let x be the associated eigenvector. Toeplitz conjectured, and Hausdorff later proved, that the numerical range of a matrix is always a convex set. (To be completely accurate, Toeplitz proved the boundary



A Blaschke ellipse with foci at a and b.



is convex, Hausdorff proved there are no interior holes.)

You have already guessed that all these things have something to do with one another. Indeed, every Poncelet ellipse is a Blaschke ellipse, and vice versa. And the triangles circumscribing a Blaschke ellipse are each the numerical range of a member of a certain family of related matrices. (The family consists of the unitary 1-dilations of a 2×2 matrix of a specific form.) And it's all constructive, you give me the ellipse, I can give you the Blaschke product and the matrix. Given the matrix, I can construct the Blaschke product and the ellipse.

We, mathematicians, love stories of surprising connections. *Finding Ellipses* by Ulrich Daepp, Pamela Gorkin, Andrew Shaffer, and Karl Voss is full of one surprise after another. The connections outlined above are thoroughly and completed explored, of course. But there's more: there is a connection to dynamical systems and another to, of all things, Benford's Law. The middle part of the book extends the investigation described above to questions involving Blaschke products of degree higher than three. Poncelet-like properties are discovered and explored along with deep function-theoretic properties of Blaschke products.

LETTER TO THE EDITOR

Sometimes True?

"If S is a rectangle, then S is a square." Is this statement true, sometimes true, or false?

I hope it's false since I know a few counterexamples.

But the article on page 32 of the Apr/May 2018 issue of MAA FOCUS leads me to believe the authors might categorize it as sometimes true.

I hope not. I don't teach math, but I know the statement is false.

If the authors have invented a new logical option, then they stand to confuse a lot of students and make MAA FOCUS look rather silly.

I hope I'm misreading. Otherwise your mailbox should be filling up pretty quickly.

[Btw, I conjecture that *ST* means that two sets have nonempty intersection. Even so, it's embarrassing terminology.]

Dennis Bernstein
Professor
Aerospace Engineering Department
University of Michigan

Response from the authors:

Thank you for reading our article and calling attention to our misphrasing of the first example, which was originally a True/False question. The statement should be: "Let $\phi: G \rightarrow G'$ be a monomorphism. Then $\phi(G) = G'$." This is why, in practice, conditionals are not suitable when using the Sometimes True category. Regardless, the purpose of this article is to use conceptual True/False questions in teaching abstract algebra. As with any pedagogical technique, if the instructor is unable to clearly implement the technique without doing harm, then we encourage the instructor not to use it. In terms of this article, the purpose is to pose algebra problems rather than unnecessary logic puzzles.

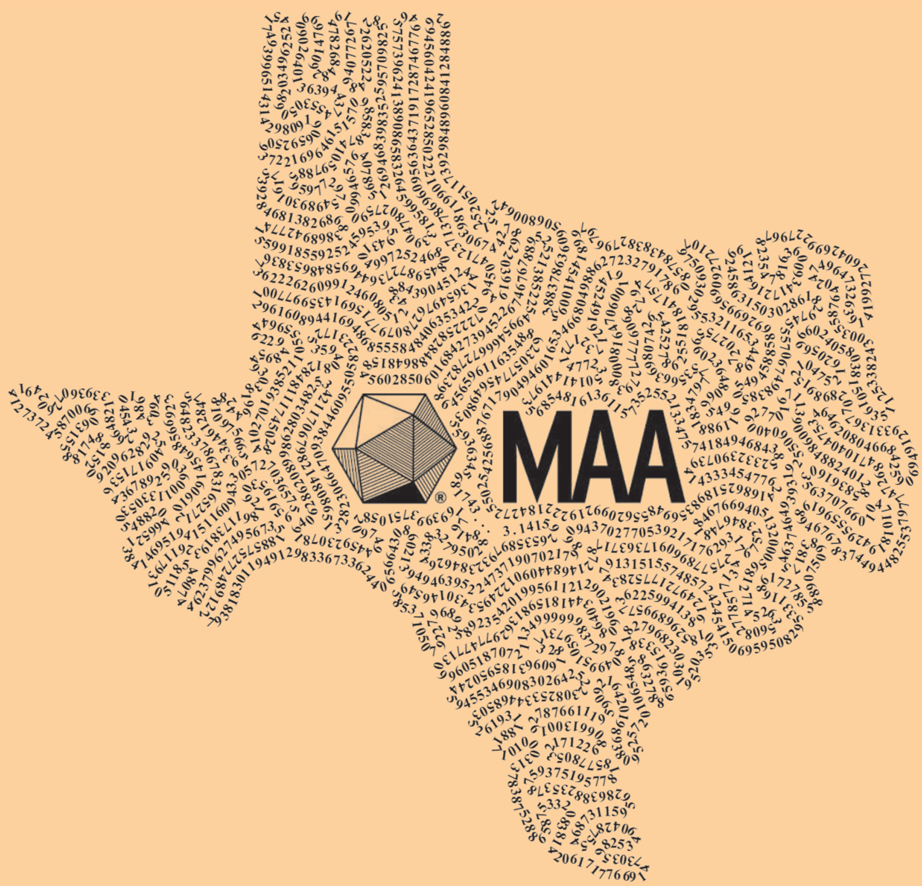
Letters reflect writers' opinions, which do not necessarily correspond with MAA policy. Please keep letters cordial and no more than 300 words. Letters will be edited for style and length.

The exposition throughout is crystalline and larded with illuminating examples. Reading this book would make for a great capstone experience for an undergraduate math major. She would learn some projective geometry, some linear algebra, and lots and lots of complex analysis. With this use in mind, the authors include a concluding fifty-page chapter full of questions and challenges ranging from exercises to deep, open questions suitable for launching a research project.

If you don't want to supervise a student reading, do what I did. Sit on the couch with this book and a pad of paper and watch as complex analysis and linear algebra and projective geometry delightfully illuminate one another. ■

Stephen Kennedy (Carleton College) manages acquisitions for MAA Press. Contact him if you're interested in writing a book for MAA Press: kennedy@maa.org.

FOUND MATH: Pi MAA



—Submitted by John Snow of Mary Hardin Baylor

TOOLKIT

Using 3D Modeling and Printing Projects in College Math Courses

—Brian Hollenbeck and Qiang Shi

A 3D printer allows users to create 3D models and fabricate objects, and the use of 3D printers in education has become quite popular over the last few years. Some examples include using 3D printed models of organs or molecules for students to explore. We are investigating how to appropriately integrate this promising technique into college mathematics courses, especially for creating projects in which 3D modeling naturally intertwines with the mathematical content. We also wanted students to be involved in the design process for at least one project. In fall 2017, under a grant from the Emporia State University Foundation, we were able to purchase a MakerGear M2 3D printer with Simplify3D software and developed several 3D printing projects for a variety of college math courses.

Examples of Projects

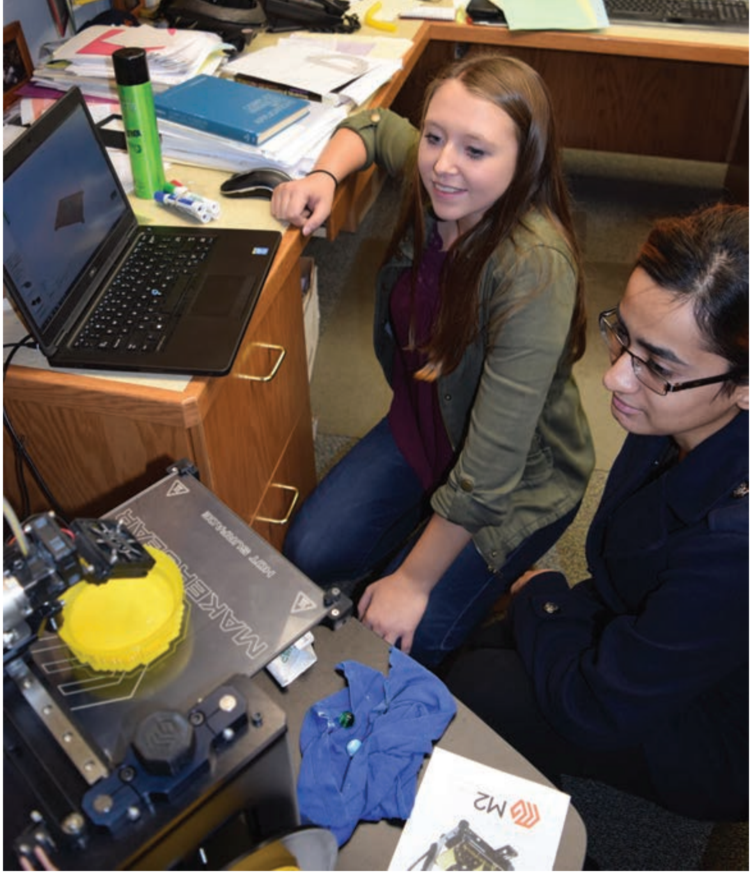
In college algebra, Shi developed the project Hyperbolic Functions, Gateway Arch, and 3D Printing. The project introduced the definition and properties of hyperbolic functions and required students to use a hyperbolic function to design a 3D model of the Gateway Arch. The entire design process was completed by using free online resources. Students first used Desmos to draw a hyperbolic curve that represented the central curve of the Arch. Then using Selva3d, students converted the curve to a 3D object. Finally, students imported the curve into Tinkercad, designed a base for the Arch, and put together the curve and the base to make a model of the Arch. Shi also developed the project Volumes of Solids of Revolution for his calculus II class. Students used cubic splines to model the outline of a pear and then used definite integrals to calculate its volume. Using the computer algebra system Maple, students built a 3D model of the pear. Students compared the pear model with the real pear to discuss how to improve the accuracy of their model.

Ce Jae, Paige, Henry and Aaron holding their water slide model.

In mathematical modeling, Hollenbeck used the 3D printer for multiple projects. In How Many Kisses®?, Hollenbeck designed and printed a vase based on the rotation of a particular polynomial about the vertical axis. The vase was then filled with Hershey's Kisses®. Students had to use modeling techniques to find the curve that described the outline of the vase. Students used calculus to find the volume and then predicted the number of candies in the vase. Afterwards, one student recommended that students be asked to design a vase to hold a predetermined number of candies. In Design Your own Water Slide, students were asked to design a water slide to propel a swimmer off a cliff into a lake below. To shrink the scale of the assignment, students designed a prototype, where a marble would represent the swimmer. First, they needed to choose a function which would create an entertaining tube, while maximizing the distance traveled by the marble. Next, students used the tubeplot command on Maple to create a 3D representation of a tube that could be exported as an STL file. Finally, they used OpenSCAD to design a target for the marble. Points awarded were inversely proportional to the size of the target the marble landed in. One student recommended a multi-level tube design for a future project.

Outcomes

Those projects enhanced and improved students' understanding of the relevant math concepts. In addition, students learned the basics of 3D modeling and design, and they enjoyed the fact that they were able to visualize and manipulate the real outcome of their designs. Students gave positive feedback about their experience with those projects. 25 out of 30 students we surveyed either strongly agreed or agreed that "The overall project experience has been valuable." One student commented, "This project made me gain interest in 3D printing." Another student said, "having no previous experience with 3D modeling, this project was very informative to understand the basics of such a task." Overall, we believe those 3D printing projects have provided a unique and highly impactful learning experience for our students.



Cortnie and Sanya watching the 3D printing process.

A Few More Tips

Both authors are newbies of 3D printing technology. When we were developing those projects, we intentionally chose to use both commercial and free software. Commercial programs seem to be more reliable and require less maintenance. However, considering many of our students are education majors, we also want them to learn how to use free programs to create 3D models. We hope someday they may be able to use 3D printing in their own classrooms. In terms of the printing process, we found that perseverance and creativity are important. For instance, the slicing software will not always slice your 3D object as you expect. A change in orientation on the plate, changing the thickness of the object, or other alterations may be needed. Some tubes in the water slide project had to be redesigned to be longer than needed so they would slice properly. We then used a hacksaw to remove the excess tube. Time is another factor to be aware of. Enthusiasm for the water slide project led some students to create elaborate designs. However, printing the tubes and targets for six groups took nearly 60 hours. If the printing is not spaced out, print jobs will need to be started during evenings and weekends. ■

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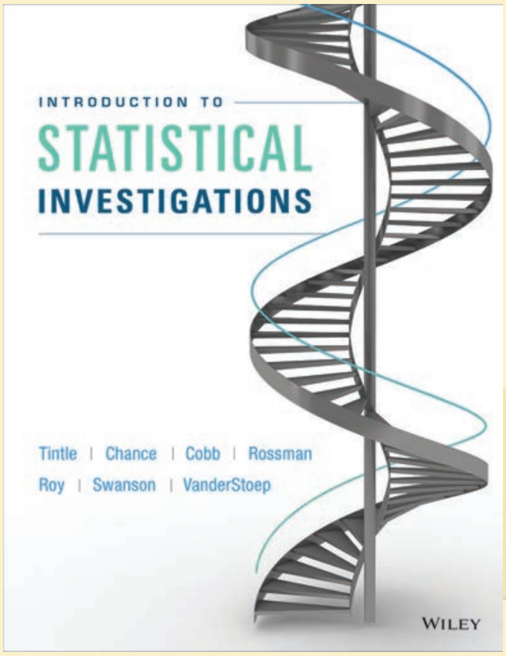

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