

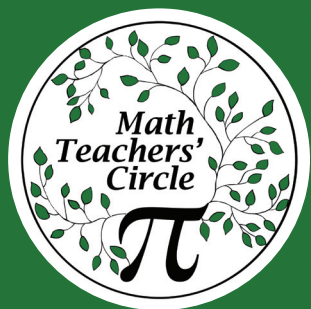
MTCircular

Summer/Autumn 2014



THE STATE OF THE CIRCLES

National Survey Shows
Scope of MTC Impact



Art Meets Math Geometric Symmetry and Escher
New Heights in Hawai'i Featured Circle
Dispatches Nationwide MTC Updates
Problem Circle Possible Paths

A Wider View, a Closer Look

Dear Math Teachers' Circle Network,

This issue brings you both macroscopic and microscopic views of the Math Teachers' Circle Network.

Our lead article, "The State of the Circles" (p. 4), presents some major results from an ongoing study funded by the National Science Foundation. On a national survey with more than 200 respondents, teachers reported that belonging to a professional mathematical community is one of the most important reasons they participate in MTCs, and many respondents told us about ways in which they have grown mathematically, pedagogically, and professionally as a result of their participation.

"The State of the Circles" also reports on a year's worth of data on MTC meeting participation, topics, and session leaders. Visit our session materials page at <http://www.mathteacherscircle.org/resources/session-materials/>, where you'll find a number of new sessions contributed by MTC leaders from around the country. If you have any sessions you'd like to add to our list, please get in touch!

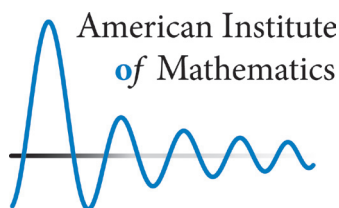
A challenge facing our network is how best to support Math Teachers' Circles that have made it beyond their first year. Some of your thoughts about this issue are summarized on p. 9, and we look forward to continuing this conversation in the coming months.

And now for the microscopic view: All MTCs share the goal of creating a mathematical community of teachers and mathematicians focused on the practice of mathematics, but every MTC realizes this vision somewhat differently based on their local resources and needs. I truly enjoyed learning more about the dynamic Math Teachers' Circle of Hawai'i (MaTCH), featured on pp. 10-13. I hope that their exemplary practices and innovations will inspire others as well.

Happy problem solving!



Brianna Donaldson, Director of Special Projects



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THE STATE OF THE CIRCLES

National Survey Shows Scope of MTC Impact

By Hana Silverstein

Back in 2011, the Math Teachers' Circle Network was five years old and growing fast. Forty-four teams from 26 states and one U.S. territory had attended "How to Run a Math Teachers' Circle" workshops, and 36 of those teams had successfully started a Math Teachers' Circle. Teachers were reporting increased confidence in their teaching and their mathematical problem solving ability.

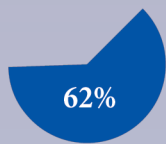
The Math Teachers' Circle Network was shaping into a promising model for teacher professional development. It had the potential to be cost-effective, scalable, and sustainable over the long term. But there was little beyond anecdotal evidence to describe the MTC model, how it was implemented at the local level, or what impact it had on teachers.

Thanks to a Discovery Research K-12 grant awarded in 2011 by the National Science Foundation, a team of researchers and AIM staff began working to develop our understanding of Math Teachers' Circles and how they affect participating teachers. The team includes Brian Conrey, Brianna Donaldson, and Hana Silverstein, AIM; Michael Nakamaye and Kristin Umland, University of New Mexico; and Diana White, University of Colorado Denver.

An important component of the project has been an annual online survey, entirely voluntary and anonymous, to learn more about how Math Teachers' Circles have affected participants' mathematical, pedagogical, and professional growth. Our preliminary analysis of the 2013 survey data follows. We are grateful to the 220 survey respondents and excited to share our findings on how Math Teachers' Circles have affected teachers around the country.



Why do you participate in Math Teachers' Circles?



Sixty-two percent of survey respondents said they participate in their local MTC because they enjoy being part of a professional development community of math teachers – whether this means a chance to network professionally, collaborate on problems, or just hang out with fellow “math nerds.”

Fifty-seven percent said they participate in MTC because “learning is fun!” They enjoy the chance to refresh their math skills and solve problems. Forty-three percent of respondents said that their MTC helps them improve their teaching and provides new strategies and materials to take back to the classroom. Fourteen percent were motivated by other factors, including professional development credits, stipends, and, of course, food.

One respondent summed it up: “It’s a fun way for me to keep connected to other professionals. Also, it keeps me excited about doing mathematics and keeps fresh in my mind how resilient my students have to be to do the tasks I ask of them.”

Have you grown mathematically as a result of participating in Math Teachers' Circles, and how?



Ninety-seven percent of respondents said they have grown mathematically as a result of participating in MTCs.

Thirty-three percent reported a deeper understanding of specific mathematical topics, including fractions, geometry, number theory, and probability, among others. Sixty-three percent said they have gotten better at the practice of doing math.

“My ability to persevere in solving problems has improved,” said one teacher. Many said they learned to work collaboratively on problems. Others have become more flexible, creative thinkers: “I can come at problems – and help students come at them – from more than one way.”

Please list one or two specific things about your teaching that you have changed as a result of participating in Math Teachers' Circle, if applicable.



Eighty-four percent identified at least one thing they had changed about their teaching as a result of participating in Math Teachers' Circle.

Of those respondents, 44 percent mentioned content (what they taught), 54 percent mentioned their instructional practices (how they taught), and 14 percent mentioned their expectations regarding their students' learning process.

One of the most commonly identified changes included bringing more interactive activities and non-routine problems to the classroom: “We recently learned a hands-on way to teach division of fractions, which I plan to use next year.”

Also, many teachers have changed the way they talk about math in the classroom: “I ask more questions to lead students to get the solutions for themselves rather than giving the solutions away.” Another respondent added, “I expect students to explain their thinking in math more than previous school years.” Others reported giving students more time to think and collaborate on problems: “I have learned to let students struggle for a little while before offering help. I allow students to help each other.”

Do you see any connections between what you’ve learned in your Math Teachers’ Circle and the Common Core?



Of the 86 percent of total respondents who use the Common Core, eighty-one percent indicated that they saw a connection between what they had learned in their MTC and the Common Core.

Numerous connections were noted, with 61 percent mentioning the mathematical practice standards, 36 percent noting connections to content, and 36 percent describing pedagogical or other classroom connections.

“First and foremost, the Common Core is not just old standards packaged differently, but actually a deep shift in how we teach,” explained one teacher. “My Math Teachers’ Circle has helped me understand the CCSSM by creating an environment where I am a learner of the new Common Core. I have experienced the shifts and the Mathematical Practices firsthand, and because of that experience, I see the difference and what the shifts actually feel like as a student.”

Has participating in your local Math Teachers’ Circle affected your professional activities outside the classroom?



Forty-five percent said that MTCs have affected their professional activities outside the classroom.

Of those respondents, 18 percent reported new collaborations, especially with teachers at different schools or districts. Eleven percent became involved in decisions about curriculum. Eleven percent participated in conferences and workshops, took additional math classes, or joined other math-related organizations. Another eleven percent took on leadership roles at conferences, workshops, and at their schools. Four percent became involved in extracurricular student activities, such as math clubs and contests.

“It has opened many doors for my future,” noted a respondent. “I was a team leader for my school. I participated in curriculum mapping for my school and was able to attend and present at many different math conferences. I also have moved into my current position as Assistant Principal.”

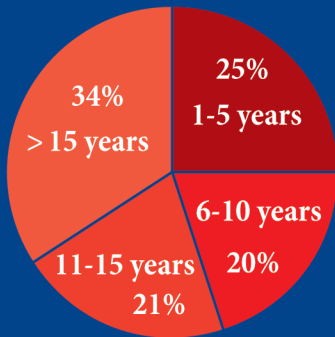
The survey also asked teachers to share how they saw MTCs fitting in with the other professional development they participated in. A common observation among respondents was that MTCs provide scholarly and social support that isn’t always found in other forms of professional development. “It is helpful to have an ongoing professional development community,” said one teacher. “The opportunity to practice active research is helpful.”

SURVEY DEMOGRAPHICS

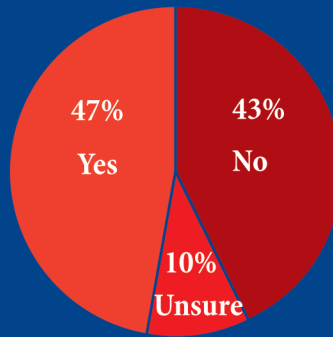


220 respondents from 25 MTCs nationwide ♦ 25 percent male, 72 percent female (3 percent declined to state)

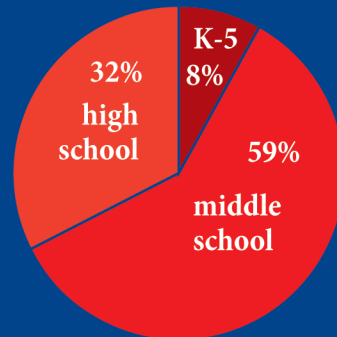
Years of Teaching Experience



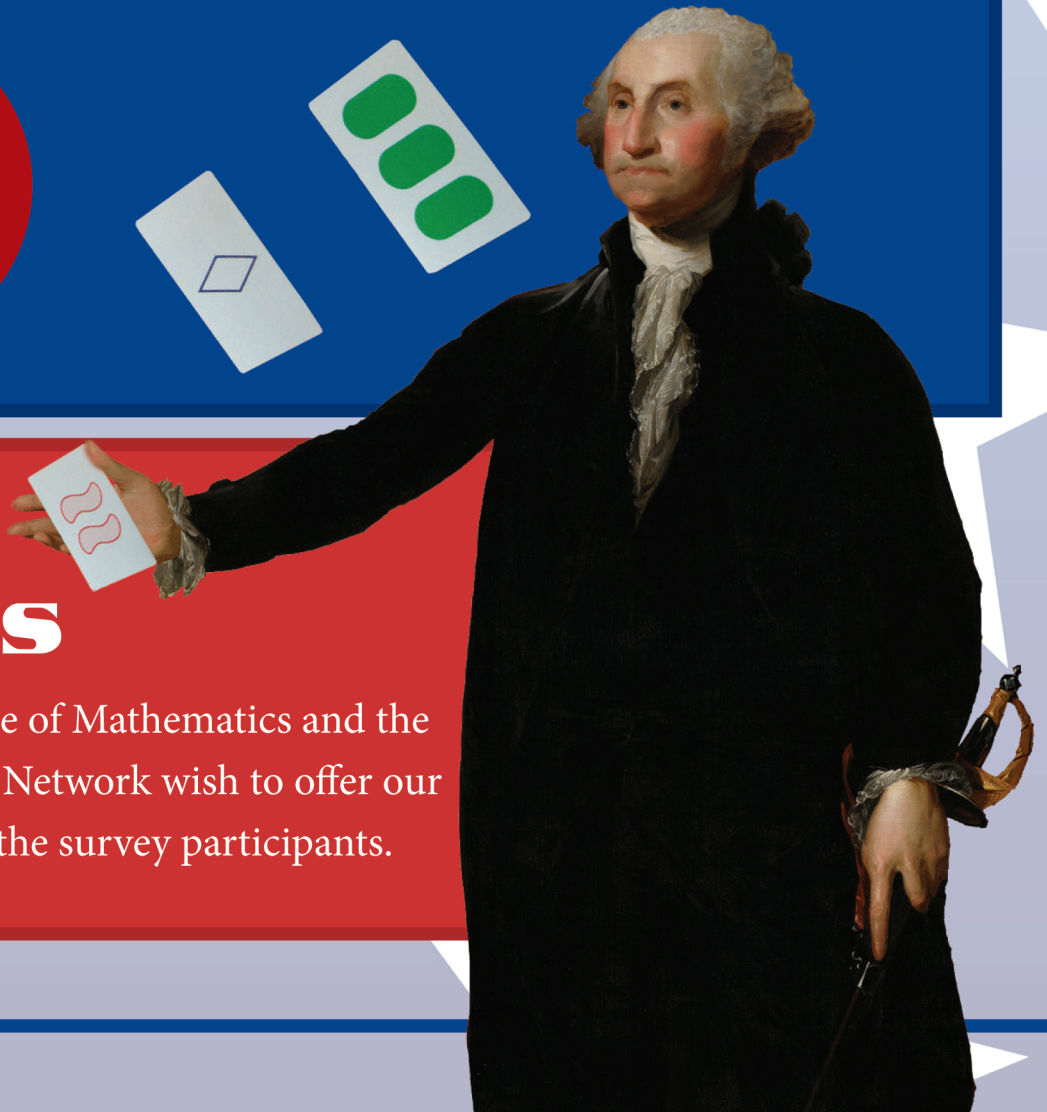
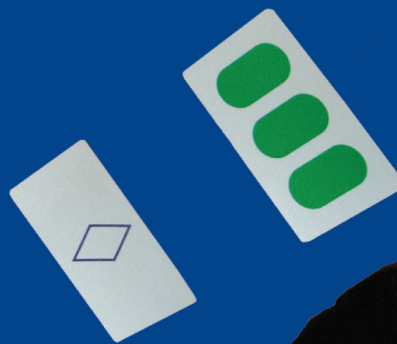
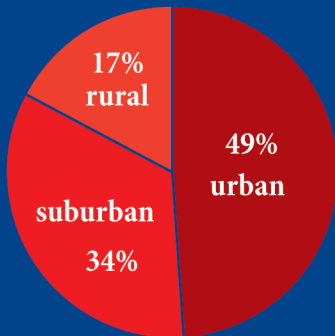
High-Needs School



Grades Currently Teaching



School Setting



MANY THANKS

The American Institute of Mathematics and the Math Teachers' Circle Network wish to offer our heartfelt thanks to all the survey participants.

MEETING SURVEY RESULTS

Since September 2013, we have also been sending out a short survey to MTC leaders, asking them to tell us about their meetings. So far, 26 MTCs have participated in the survey. Collectively, they have told us about 100 meetings. Here's what we've learned so far:

How many teachers participate in MTCs?

An average of 16.5 teachers participated in each meeting.



Out of 26 MTCs that responded to the survey, eight had an average of 10 or fewer participants per meeting, fourteen averaged between 11 and 20 participants, and four averaged more than 20. If we have a representative sample of MTCs responding to our survey, we would expect that approximately 990 teachers participate in the 60 active MTCs. Taken together, these teachers are reaching approximately 100,000 students!

How many session leaders are involved?

A surprisingly high 95 leaders were involved in the 100 meetings for which we have data. Only 14 people led multiple sessions. Thirty people were involved in co-leading a session. Altogether, 15 sessions were co-led. Twelve sessions were led by a guest visiting from another MTC.

What session topics are MTCs using?

About 84 distinct session topics were represented in the 100 meetings! Twenty-five meetings drew on the MTC Network website or newsletter, and 75 used other topics. We are proud to announce that, as a result of the meeting surveys, we now have 26 new sessions (all marked with **NEW!**) available on our website at <http://www.mathteacherscircle.org/resources/session-materials/>.

How do I participate in the meeting survey?

Each semester, we e-mail the MTC leaders to ask about upcoming meetings and invite them to participate in the meeting survey. You can also submit meeting information at any time using the forms available on our website at <http://www.mathteacherscircle.org/upcoming-workshops/calendar/>.

How do I share my materials with the MTC Network?

For now, please email them to Hana Silverstein at hana@aimath.org. Stay tuned for a new way to upload your materials that will let you easily enter keywords and other annotation. We hope to give you the details in the next newsletter!

A SUSTAINABLE MTC

In a recent informal survey, we asked MTC leaders what factors have enabled their MTCs to be successful over the long term, as well as what challenges they face regarding long-term support. Perhaps our favorite response was: “Blood, sweat and tears. Committed leadership. Endless good problems.” Here are some other key factors.

Community participation

Most groups cited their biggest success as the creation of a supportive mathematical community with committed members. “I have a core group of 15 to 20 teachers who regularly attend sessions and who are enthusiastic about the program,” wrote one MTC leader. “Their appreciation has been a big factor in motivating me to keep the program going.” Another wrote, “I now have a group of colleagues who are happy to be guest presenters.” Multiple leaders cited the involvement of math graduate students as an unanticipated positive outcome.


A strong leadership team

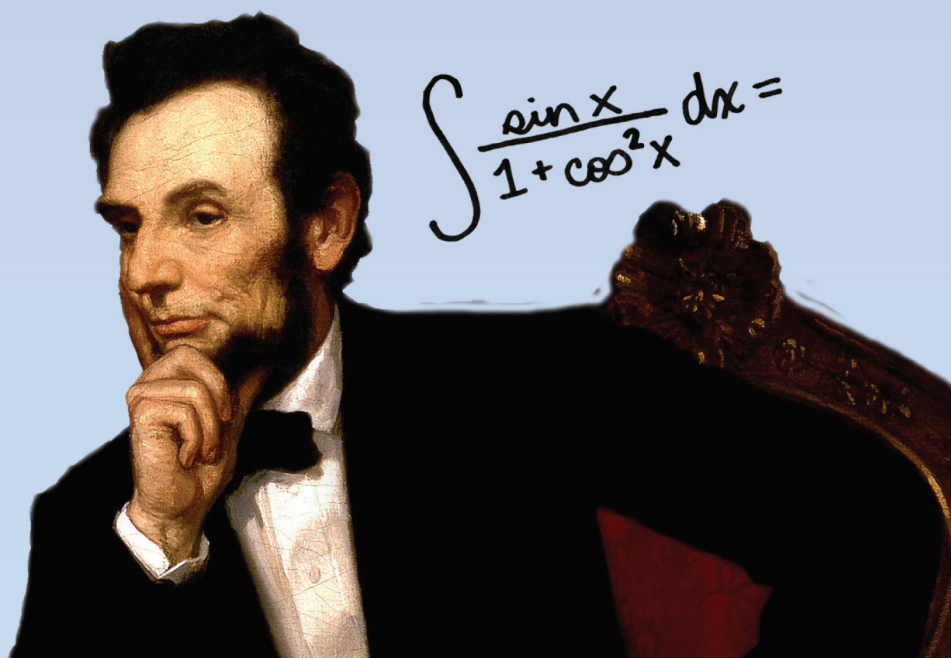
Having a team of leaders, rather than one individual who takes on all the administrative responsibilities, is critical for the long-term health of MTCs. Describing a leadership team of five, one respondent wrote, “We try to share the responsibilities: each person is in charge of a part or two and we know we will always help with whatever someone needs.” In the reverse situation, a lack of partners can have serious consequences for the longevity of a MTC. Wrote one respondent, “If I cannot find some partners, then I will seriously consider ending our MTC. I hate to say that, because I really enjoy this and I think it is important, but the necessary administrative work just isn’t going to get done if I am the only one doing it.”

Institutional backing

Support from leaders’ and participants’ institutions is key to supporting their efforts and encouraging longevity in MTCs. Several respondents cited strong backing from school districts as a major factor driving teacher participation. Others wrote that they appreciated the involvement of their faculty and graduate student colleagues as session leaders. Still others wished for more visibility and recognition within their department or school district.

Ongoing financial support

Ongoing financial support is also key to the long-term continuation of MTCs. Some groups do not have access to such funding and have struggled to piece together financial support. “Foundations in our area have said that we are not a good fit for their missions, or they have not had multi-year grants,” wrote one respondent. However, other groups have had success finding ongoing support through small grant programs, pieces of larger grants, and discretionary funds from mathematics departments or school professional development offices. 



Hitting New Heights in Hawai'i

by Brianna Donaldson

The thriving Math Teachers' Circle of Hawai'i (MaTCH), founded in 2011, draws on the talents of teachers, faculty, and graduate students to organically integrate mathematics, teaching, research, and technology.

Part of the secret to MaTCH's success seems to be that co-founders Michelle Manes (Associate Professor of Mathematics, University of Hawai'i), Linda Venenciano (Assistant Professor of Education, University of Hawai'i), and Seanyelle Yagi (Formative Instruction Resource Teacher, Hawai'i Department of Education) have a penchant for approaching challenges as opportunities. Take their group's size, for example. MaTCH has consistently had high participation, but interest spiked this year, when a well-known State Department of Education math coordinator, Dewey Gottlieb, advertised it as a way to earn professional development credits. In searching for a room large enough to accommodate more than 40 people, the leaders wound up reserving a high-tech collaborative classroom. The new surroundings have invited experimentation. For example, Venenciano said, "During one session, we were modeling bee populations using rice scattered on paper. You don't really want to walk that up to the doc cam. The session leader snapped photos on her iPad of what each table was doing and was then able to share the photos with everyone by projecting back to monitors at the tables."

Using Technology to Overcome Geography

Another challenge-turned-opportunity has been the geography of the group's home state, with a population distributed across numerous islands. For the first two years of MaTCH, teachers from neighboring islands would fly in for MaTCH meetings, funded by the broader impacts portion of Manes's NSF research grant, and would spend their whole day in transit

or at the four-hour meeting. According to Manes, they started asking themselves, "How can we serve teachers on neighboring islands in a way that doesn't require lots of ongoing funding and travel, for either participants or facilitators?"

With the support of an Elementary and Secondary Education Act, Title IIA grant, they brought in two consultants from the Education Development Center (EDC) to train the MaTCH team and two teachers from the neighboring island of Moloka'i on how to use Google Hangouts to involve remote participants. At the next MaTCH meeting, three teachers from Moloka'i "hung out" with 40 of their colleagues in Oahu at an "e-table" that was mixed in with the rest of the tables in the room. EDC consultant Bowen Kerins, who also consults for TV game shows, led a session in which participants analyzed the mathematics behind Price is Right games. Throughout his session, Kerins also demonstrated strategies for integrating remote participants into the "live action." Manes explained, "He had some interesting ways of keeping us on an even footing. For example, he had one remote person be a contestant while he was host. Also, every 15 minutes or so, he would have us write something on a check-in spreadsheet in Google Docs and send a picture of what we were doing to a Flickr account. This was a chance for us to reflect on where we were in our work, and it also let him select what to focus on next. He would pick out a few pictures and ask the person who took them to describe what they were doing."

The leaders look forward to incorporating more remote participants into future meetings. "We haven't figured out yet exactly where this is going, but originally we thought of having an e-table for each of the neighboring islands—Kaua'i, Maui, Moloka'i, and the Big Island of Hawai'i—plus the tables for participants in the room," said Manes.

Vertical Integration for a K-20 Community

From its inception, MaTCH has included elementary, middle, and high school teachers. There are challenges inherent in such a mix, but also benefits. According to Manes, herself a former elementary teacher, “We have gotten feedback from some elementary teachers that they would like to see a MTC for elementary teachers only, but a real positive about the range of backgrounds is that it gives them more of a chance to stretch. There’s a real value for everyone to seeing lots of approaches. The high school teachers tend to jump right to formulas. It’s good for them to see that there are other types of solutions.”

MaTCH has also capitalized on opportunities to involve graduate and undergraduate students. For instance, the Department of Mathematics at the University of Hawai‘i at Manoa has a GK-12 grant from the National Science Foundation that supports mathematics graduate fellows in partnering with local schools. From its inception, MaTCH was conceived as a way that these graduate students could continue their work with local teachers. Manes has worked with several GK-12 fellows over the past three years to coach them through the process of leading a math session for MaTCH teachers.

Venenciano works with both undergraduate and graduate students in the university’s teacher training program. She requires all her students to attend at least one MaTCH session so that they can interact with the teachers, who will in many cases be their future colleagues, and also so they can see a different style of teaching than they may have been exposed to as younger students. In addition, education graduate assistants have helped with handling logistics as well as various aspects of data collection for MaTCH.

As the project has grown, Manes and Venenciano have included their mathematician and mathematics educator colleagues in MaTCH activities. Interactions among these faculty and MaTCH teachers have led MaTCH teachers to participate in other mathematics professional development activities, such as Monte Carlo Night and the Ethnomathematics and STEM Institute at the University of Hawai‘i’s West Oahu campus.



From top: In a session activity, grains of rice provide a simulated depiction of a population of bees for counting. Teachers generate data by simulating football plays in an investigation of functions. MaTCH participants learn about the context for a modeling problem.

All photos courtesy of MaTCH

Integrating Research with Education

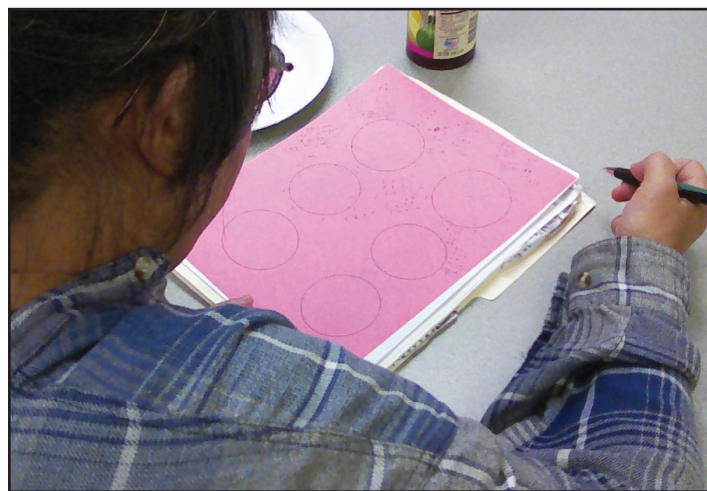
Mathematically, MaTCH sessions often tie in with active research areas in some way. For instance, Manes led a session focused on this problem: “9 can be represented as a sum of consecutive counting numbers (4+5); so can 10 (1+2+3+4). Which numbers can and can’t be represented this way?” She planned to conclude the session with a short introduction to the Goldbach conjecture (every even number greater than 2 can be expressed as the sum of two primes).

Connections with other disciplines have also formed the basis of some unusual and rewarding sessions. For example, Manes met Alexis Rudd, a graduate student from the zoology department, through the Graduate Women in Science program. “She kept emailing me about math that was coming up in her research in bioacoustics. She drags a microphone behind a boat and tries to determine the location of whales based on the data she gets. She finally told me, ‘It all comes down to the distance formula! Why didn’t they tell me in school that you could use the distance formula to find whales?’” Together, Manes and Rudd developed a session based on Rudd’s research. “She started out by giving a short presentation about her work, then we basically gave people a bunch of data and said, ‘Here’s the data that Alexis received from her microphone. Where’s the whale?’”

Another favorite session involved ethnomathematics, which can be described as the intersection of mathematics with a social, cultural, and historical context. “We had a crew from a traditional Polynesian canoe come in, and one of the guys was apprenticing to become a navigator,” said Manes. “He taught us about traditional navigation, and we built a star compass!”

Developing Teacher Leaders

The first 2.5 hours of MaTCH meetings are devoted to working on mathematics, and then the group shifts gears to focus on teaching for the last 1.5 hours. The group’s pedagogical discussions have evolved over time to meet the changing needs of the teachers. For example, during the group’s second year, the discussions emphasized links with the Common Core, particularly the Standards for Mathematical Practice. This year, the MaTCH leaders used the pedagogical time for teachers to share their own classroom experiences related to their participation in MaTCH. Again, this was a case of taking advantage of a potential challenge. Manes explained, “Many of the teachers get professional development course credits through the Hawai‘i Department of Education. If they repeat any course, including MaTCH, for credit, they have to do something new the next time.”



Left: A group on a neighboring island shares via Google Hangouts during a class discussion. Right: In a MaTCH activity, teachers step into the shoes of students.

Teachers in their first year of MaTCH participation are asked to develop a portfolio that includes reflections and samples of their mathematical work from each session they attend, as well as several lesson plans reflecting mathematical content or new approaches that they have learned. By their third year, teachers are required to give a presentation either to MaTCH or at a state-level conference. For example, one elementary teacher received funding through MaTCH to attend a workshop on manipulatives, and he then presented to the group about what he had learned. A high school teacher did a presentation on modeling activities that he characterized as “Dan Meyer-style activities if you’re technologically incompetent.” He introduced Meyer’s version of the activities and talked about some low-tech adaptations that he used in his own classroom. Manes said, “All the teachers were nervous before doing these presentations, but they came off so well. I really feel that this aspect of the program has helped us develop a cohort of math leaders, some of whom I think will continue on to become more involved at the state level.”

The Future of MaTCH

Administrators at the University of Hawai‘i have met the achievements of MaTCH with enthusiasm.

According to Kathleen Berg, Director of the Curriculum Research & Development Group in the University of Hawai‘i’s College of Education, “Each time I talk with Dr. Venenciano about her Circle work, her excitement is evident and contagious. It is inspiring to hear about the Saturday gatherings of the mathematicians, educators, and mathematics educators who together solve mathematics problems and further their content knowledge and problem solving experience to make them better teachers. What better way is there to spend time, I say, as a former math teacher myself?”

While thrilled with the level of interest that MaTCH has generated, the leaders admit that it would sometimes be nice to work with a smaller group. They have begun exploring the possibility of helping start another branch of MaTCH with interested faculty from another campus of the University of Hawai‘i that is also located on the island of Oahu. The two MaTCH locations could either serve participants based on geography, or perhaps they would split up according to grade levels taught by the participants.

Despite all the hard work involved in developing MaTCH, “It’s been a great few years!” said Venenciano. With all the challenges and opportunities on the horizon, MaTCH is on course for many more. ☐



Left: A team of teachers uses colored tiles to study patterns. Right: In one of the first Google Hangouts attempts, a teacher from neighboring island participates in a session.

All photos courtesy of MaTCH

Advisory Board Member Richard Rusczyk Honored With Paul Erdős Award



MTC Advisory Board member Richard Rusczyk, the founder and CEO of the math education website Art of Problem Solving (<http://www.artofproblemsolving.com/>), has been awarded the 2014 Paul Erdős Award by the World Federation of National Mathematics Competitions (WFNMC). The Erdős Award, named after prominent and prolific Hungarian mathematician Paul Erdős (1913-1996), was established to recognize “mathematicians who have contributed to mathematics enrichment in their own countries or internationally.” Since its foundation in 2003, Art of Problem Solving has become the world’s largest online community of avid math students in English, with over 140,000 members and over 3 million posts. ☐

Fawn Nguyen Named Outstanding Educator by Ventura County Math Council



Congratulations to Fawn Nguyen, co-founder of the Math Teachers’ Circle of Thousand Oaks (<http://www.mathteacherscircleto.org/>), who was recently named an Outstanding Educator of the Year by the Ventura County (California) Math Council. Nguyen teaches mathematics at Mesa Union Junior High School in Somis, California. Her blog, “Finding Ways to Nguyen Students Over” (<http://fawnnguyen.com/>), was recently recognized at the top of the list of “awesome K-12 math teacher” blogs by American Mathematical Society blogger Brie Feingold (<http://blogs.ams.org/blogonmathblogs/2014/03/31/awesome-k-12-math-teachers-exist-and-they-have-blogs/>). ☐


Welcome to New Math Teachers’ Circle Advisory Board Member Peter Trapa



We are delighted to welcome Peter Trapa as the newest member of the Math Teachers’ Circle Advisory Board. Dr. Trapa earned his Ph.D. from MIT and held postdoctoral positions at Harvard University and the Institute for Advanced Study in Princeton before joining the faculty at the University of Utah, where he is now Professor and Chair. His research is devoted to the mathematical theory of symmetry. In 2007, he helped found the Utah Teachers’ Math Circle, one of the oldest continuously running Circles in the MTC Network. He currently serves as Director of the National Association of Math Circles, based at the Mathematical Sciences Research Institute. ☐


Encouraging Mathematical Collaboration: AIM Partners with Julia Robinson Math Festival

Since its first event at Google in 2007, the Julia Robinson Mathematics Festival has been encouraging and developing young students' interest in math. Now partnering with the American Institute of Mathematics, JRMF is working to increase the number of Festivals, with over a dozen events across the country during the 2013-2014 academic year. JRMF provides a collaborative, non-competitive atmosphere in which students explore inspiring, thought-provoking problems with other kids and older mentors. According to the Festival's Mathematics Director, Joshua Zucker, "The goal of the Festival is to provide an alternative to the traditionally competitive culture of math contests. We offer intriguing and challenging problems, puzzles, and activities, and a supportive setting for kids who like to take their time working on problems." At the Festivals, tables are dedicated to different problems and activities, each with a mathematician to offer guidance and encouragement. "Students choose a problem and make whatever progress they can, they get help, they work with other kids, and eventually they come to some kind of stopping point and go find another activity of interest," said Zucker.

"Like Math Teachers' Circles, JRMF is a great fit with AIM's mission of encouraging mathematical collaboration," said Brian Conrey, Executive Director of AIM. Conrey noted that Math Teachers' Circle participants might be interested in exploring JRMF's growing archive of problem sets, many of which start with entry-level questions and become steadily more challenging. He added, "Working together to organize a JRMF at their schools could be a great project for a Math Teachers' Circle to take on. It would be a low-pressure way to get some more experience teaching with a focus on problem solving." To learn more, including materials, upcoming events, and information on starting a JRMF in your community, please visit <http://juliarobinsonmathfestival.org> or email Festival Director Kristie Sallee at info@juliarobinsonmathfestival.org. 

Math for America Seed Grant Recipients

Thanks to the continued generosity of Math for America, AIM was again able to award seed grants to new MTCs this year. Congratulations to the following 2014 Math for America seed grant recipients:

- Boston Math Teachers' Circle (Cambridge, Mass.)
- Central Upper Peninsula Math Teachers' Circle (Marquette, Mich.)
- Columbus Math Circle (Columbus, Ohio)
- Eastern Upper Peninsula Math Teachers' Circle (Sault Ste. Marie, Mich.)
- Gold Coast Math Teachers' Circle (Boca Raton, Fla.)
- Iowa Heartland Math Teachers' Circle (Des Moines, Iowa)
- Montana Math Teachers' Circle (Billings and Missoula, Mont.)
- New Haven County Math Teachers' Circle (New Haven, Conn.)
- Oklahoma City Math Teachers' Circle (Oklahoma City, Okla.)
- Rutgers Math Teachers' Circle (Piscataway, N.J.)
- South Mississippi Math Teachers' Circle (Gulfport, Miss.)
- Tucson Math Teachers' Circles (Tucson, Ariz.)
- Tulsa Math Teachers' Circle (Tulsa, Okla.) 

Dispatches from the Circles

MTC Facilitators Offer Local Updates from Across the Country

Alabama •

The **Mobile Math Teachers' Circle** recently became part of the AMSTI Professional Development Program (AMSTI PDP). The program is a collaboration between the Alabama Math, Science, and Technology Initiative and the University of South Alabama. It received a \$460,000 per year grant from the Alabama Department of Education through the Math and Science Partnership Program. Currently the program is in its second year.

The program funds a summer camp for approximately 500 local middle school students. The idea of the camp is for the participating math, science and engineering teachers to try new teaching styles in the classroom without any pressure from standardized tests or other such distractions. In particular, they have the opportunity to experience problem solving with their students. Vasiliy Prokhorov, Elena Galaktionova and I provide mathematical content and help the teachers in planning their math-related sessions. Learn more at <http://www.mcps.com/?L=0&LMID=78799&PN=Blog&DivisionID=&DepartmentID=&SubDepartmentID=&Blog=Permalink&id=5928>.

– *Cornelius Pillen*

Colorado •

We have some news to share about the **Northern Colorado Math Teachers' Circle**:

- Dr. Katie Morrison, one of the leaders of our Northern Colorado MTC, is now the president-elect for the SIGMAA on Math Circles for Students and Teachers.
- We will run our second summer institute at YMCA Estes Park from June 23-26, 2014. Paul Zeitz will be our invited presenter.

- We received two sources of funding during 2013-2014. State Farm Insurance is funding our circle again (for the third time, for \$9,759), and BBVA Compass Foundation is funding our circle again as well (for the second time, for \$2,000).

– *Gulden Karakok*

Connecticut •

Our **Fairfield County Math Teachers' Circle** was awarded two mini grants of \$1000 each from People's Bank and GE in August 2013 due to the efforts of my colleague/co-organizer Rosemary Danaher.

– *Hema Gopalakrishnan*

Oklahoma •

Thanks to a gift of \$25,000 from the Schusterman Family Foundation, the **Tulsa Math Teachers' Circle** is very excited to host a three-day summer immersion program for 25 middle school math teachers in June at the Post Oak Lodge. We have been very fortunate to get three outstanding session leaders to join us: Brian Conrey, Director of AIM; Richard Grassl, Professor Emeritus at the University of Northern Colorado and a member of the MTC Advisory Board; and Bob Klein, Associate Professor of Mathematics at Ohio University. All three mathematicians have great experience with leading MTC sessions throughout the country. In addition to our large gift for the summer immersion program, we were recently awarded a \$2,000 Math for America seed grant through AIM, which should help immensely with our MTC sessions in the fall of 2014. Thank you to AIM and Math for America!

– *Marilyn Howard* 

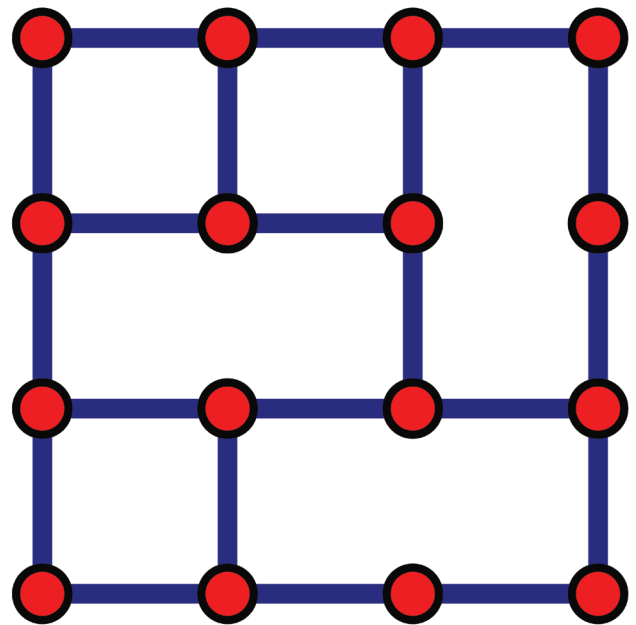
Problem Circle: Possible Paths

by Joshua Zucker

A common math contest problem is to count the number of paths from start to finish in some grid, perhaps one missing a few segments here or there to make it a bit harder to calculate. In this problem, we'll turn that usual formula around!

We'll take square grids and go from the top left corner to the bottom right corner, moving only down or right at each step. Using this rule, in the grid shown, our path has to be of length 6.

If no segments were missing, you could count the number of paths this way: Each path would involve 6 moves, of which 3 would have to be to the right. So, there are $\binom{6}{3} = 20$ possible paths. By deleting different segments, you can get any number of paths smaller than 20 that you would like. In the example at right, there are 7 paths.



Now let's turn our problem around: instead of starting with a grid and asking how many paths there are, we'll tell you how many paths there are and ask you to construct the grid!

- 1) Find a grid that has exactly 1,000 paths from top left to bottom right.
- 2) Find a grid with only one missing segment that has exactly 1,000 paths.

For each of these, the goal is to make a "small" grid. That can be measured in a few ways: smallest area, smallest perimeter, or fewest unit paths. Which is hardest? How well can you optimize your grid? Have fun! 📧

WIN A FREE MUG!

Got an answer to this issue's Problem Circle? Send it in and you could win! MTCircular will choose one winner at random from each of the six types of possible answers (smallest area, smallest perimeter, and fewest unit paths, for both problems 1 and 2). We will also send five mugs to the MTC with the most total entries. Submit your answers to problemcircle@aimath.org by August 31 for consideration.



Art Meets Math: Escher's Tilings

by Altha Rodin

The Dutch artist M. C. Escher is well known for his amazing prints of interlocking lizards, fish transforming into birds, and angels and devils intertwined, just to name a few. His intricate tilings offer a beautiful and engaging way to explore ideas related to geometric transformations and symmetries.

Escher himself is an example of someone who used mathematics extensively in his work, although he never considered himself a mathematician. By his own admission, he was unenthusiastic about his mathematics classes and found the abstract aspects of mathematics daunting. And yet, in his career as an artist, he operated as a mathematician, posing questions and investigating ideas until he reached satisfactory answers to the problem of putting down on paper what he saw in his imagination. He is, in many ways, a model of how we want our students to approach problems they encounter in the classroom and beyond.

First, a definition: A tiling, or tessellation, of the plane is a covering without gaps or overlaps, by congruent copies of one or more shapes. Escher's tessellations are often composed of intricate designs, but underlying these shapes are very simple tilings of the plane by regular polygons. A good way to begin a session on Escher-like tilings is to start with an examination of these underlying tilings. The simplest tilings to categorize are regular tilings in which all the shapes are congruent to a single regular polygon, and all polygons meet along complete edges. The question of finding all regular polygons that can be used in a regular tiling gets participants thinking about properties of regular polygons, and in particular about the relationship between the number of sides of a regular polygon and the measure of the interior angles. It does not take long to realize that there are only three regular polygons that will produce a regular tiling. At this point, it may be a good idea to ask for volunteers to

explain how they know for sure that the three regular tilings they found are the only ones. It is not hard to justify this result, but sometimes we all need to be reminded that even things that seem obvious can and should be justified.

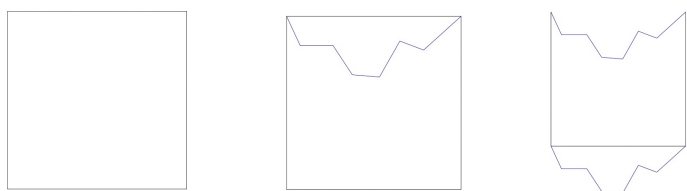
A good follow-up question, once the problem of finding all regular tilings has been settled, is to consider how the restrictions on regular tilings can be relaxed and whether the resulting tilings can be classified in some way. This is a very broad question and a whole session could be dedicated to it. The session leader may want to leave all options on the table and see where the questions that the participants come up with will lead. Alternatively, the participants can be directed toward a particular type of tiling. In the session we did on tilings with the Math Teachers' Circle of Austin, we chose the latter approach, defining semi-regular tilings and leaving the problem of finding all semi-regular tilings as a contest problem for participants to think about on their own. The necessary definitions and statement of the problem are given in the handout from that session, which is available on the [MTC website](#).

The key idea in producing Escher-like tilings is to modify each tile in such a way that the modified tile still tessellates. This is done by altering the tiles in a way that reflects the symmetries of the desired tiling. Many teachers and students alike have an intuitive understanding of what a symmetry is and can recognize symmetry when they see it, but to really understand symmetry in the way we want to use it, it is necessary to understand rigid motions of the plane, i.e., motions that preserve distances. There are four types of rigid motion of the plane: reflection across a line, rotation about a point, translation by a vector, and glide reflection. Most people are familiar with the first three. A glide reflection is simply a composition of a reflection across a line with a translation parallel

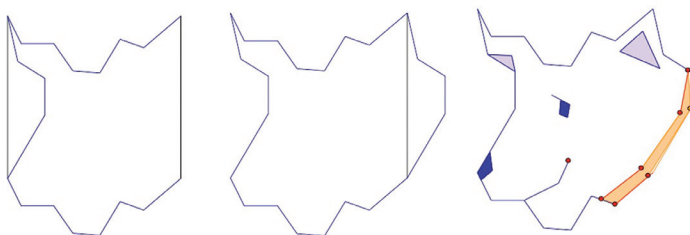
to the line of reflection. A symmetry can be described as an undetectable rigid motion. For example, a square has reflectional symmetry across a diagonal because, if someone were to reflect across that diagonal while you were not looking, you could not tell that the reflection had occurred. After introducing the idea of rigid motions, it is a nice exercise to examine some of Escher's drawings to identify the symmetries. It is interesting to consider how the symmetries are affected by coloring. As a general rule, an uncolored tiling will have more symmetries than a colored one.

Finally, it is time to get artistic. The easiest Escher-like tiling to create is one based on a square tiling of the plane, using the translational symmetry of the square tiling.

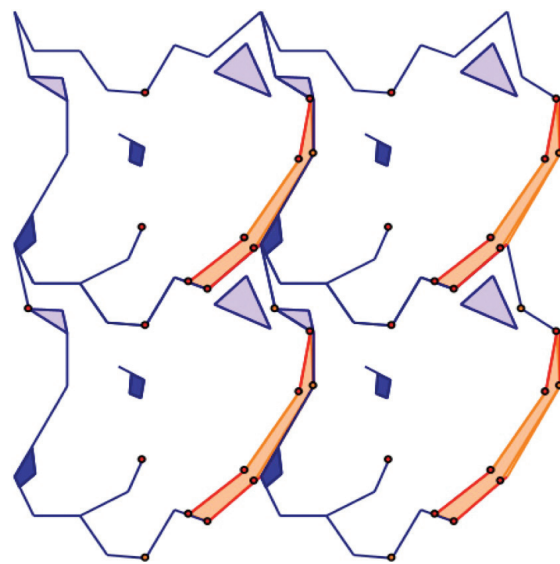
Start with a square cut out from an index card, approximately 2 inches in length, and cut a piece off of the top edge. Tape the cutout piece to the bottom edge of the square. You have translated the modification of the top edge to the bottom.



Do the same on the sides: cut a piece off of the left side and tape it to the right side and decorate.




Now you are ready to tile. Trace around the template you have made and add details.



The tiling produced in this manner has the same translational symmetries as the regular tiling by squares, but it no longer has the other symmetries, like rotational or reflectional symmetries, of regular tiling.

Next, participants can be asked to experiment with ways in which the sides of the square can be altered to maintain other symmetries of the square tiling. Alternatively, other regular tilings or tilings by parallelograms, which are often at the base of Escher's tilings, can be used as the starting point for an Escher-like tiling. The possibilities are endless, the resulting tessellations are aesthetically pleasing, and if all goes as planned, the participants walk away with a new appreciation for geometric symmetry.

For those interested in learning more about the mathematical side of Escher, check out the article "Escher as a Mathematician," by Doris Schattschneider, available on the [AMS website](http://www.ams.org). 

For links to resources related to this story, visit us online at <http://mathteacherscircle.org/newsletter>.



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