

Final Report
National Association of Math Circles
H98230-16-1-0175
July 1, 2016 to June 30, 2017

Final report on NSA-MEPP Grant H98230-16-1-0175

Background

Math Circles for students bring K-12 students together with mathematically sophisticated leaders in an informal setting, after school or on weekends, to work on interesting problems or topics in mathematics. Math Circles combine significant content with a setting that encourages a sense of discovery and excitement about mathematics through problem solving and interactive exploration. Ideal problems are low-threshold, high-ceiling; they offer a variety of entry points and can be approached with minimal mathematical background, but lead to deep mathematical concepts and can be connected to advanced mathematics. Because of this focus on mathematical problem-solving and developing participants mathematical habits of mind, Math Circles provide a relatively easy entry point for mathematicians to engage mathematically with K-12 students.

Math Circles migrated to the United States from Eastern Europe in the 1990s. Today, approximately 100 Math Circles for students are operating across the country¹. Since 1994 approximately 300 Math Circles of all types (including Math Circles aimed at teachers) have registered with the NAMC at their website (currently undergoing a major redesign), www.mathcircles.org. Math Circles adopt a wide range of practice in terms of venue, level of participants served, and type of mathematical professionals involved. The most common are ones hosted by a college or university and serving students in grades 6-8.

The National Association of Math Circles, a program of the Mathematical Sciences Research Institute, was founded in 2007 to nurture the growth of Math Circles by

- Seeding the *creation* of additional Math Circles in the United States;
- Building a *community* of Math Circle leaders through which novice and existing leaders are connected, encouraged and inspired;
- Providing high-quality resources that help Math Circles build and sustain effective programs; and
- Documenting and disseminating the *impact* of Math Circle programs across the nation.

NSA-MEPP Grant H98230-16-1-0175 provided funding for NAMC to support all four aspects of this mission. Through this grant

- We supported 15 Novice Math Circles.
- We continued the Math Circle - Mentorship and Partnership (MC-MAP) for its second year. This program supported total novice Math Circles, including a

¹ In some past application materials, we have included all Math Circles - including ones for teachers. Here we report our best numbers solely on Math Circles for students.

- training workshop bringing together approximately 40 novice Math Circle leaders and 10 more experienced Math Circle leaders who served as mentors.
- We significantly enhanced our training materials and webinar series.
 - We gathered data from both Math Circle leaders and their student participants that have allowed us to better understand the impact of Math Circles.

Math Circle - Mentorship and Partnership (MC-MAP) Program Summary

NAMC has long supported the development of new Math Circles financially and via access to suitable mathematical problems. However, we have found that this alone was not meeting the needs of our constituents. Two years ago, with funding from the 2015-2016 NSA-MEPP grant, NAMC initiated the Math Circle - Mentorship and Partnership (MC-MAP) program. The program was revised and enhanced based on post-survey data and phone interviews with mentors for the 2016-2017 academic year.

The MC-MAP Program is NAMC’s formal mentoring program. Through this program, NAMC provides training and support for novice Math Circle leaders in academic, pedagogical, and administrative components of starting and sustaining a Math Circle.

During the duration of this grant cycle, NAMC supported a total of 28 Math Circles in the 2016-2017 MC-MAP program. Funding from the National Security Agency supported 15 novice Math Circles and 5 mentors across the United States, while a separate source funded an additional 8 Math Circles (6 novice and 2 mentors) to participate. These Math Circles have supported over 800 total students, the vast majority students in grades 4-8. In addition, over half of these Math Circles specifically target an under-represented minority as their primary demographic to serve - either girls, latinx, or black students. These groups offered between 5 and 28 sessions (average = 12) over the course of the academic year, averaging approximate 100 minutes each. These Math Circles reported that the average number of attendees per session was 14, and that the average number of sessions a student attended was 8.

The following map shows the locations of the 2016-2017 participants.



Initial Training Workshop - September 15-17, 2016

The MC--MAP program is organized around and powered by relationships. As such, the cornerstone of the MC-MAP program is the initial training workshop, which brings together teams of novice Math Circle leaders with their mentors for structured planning and support. The workshop was designed to nurture rapport and community among program participants as well as to demonstrate the kinds of informal, discovery-oriented learning opportunities that are the essence of a Math Circle experience. The workshop activities allowed mentors and mentees to meet in person and begin to establish strong working relationships. Mentees learn effective facilitation techniques, learn and familiarize themselves with existing resources for finding quality Math Circle session materials, and gain knowledge of the various administrative aspects of leading a Math Circle program. In addition, a community of support is established through informal interactions throughout the conference.

Novice Math Circle leaders take advantage of the expertise of their more experienced peers through a variety of contexts during the meeting: structured planning sessions, guided observation and structured debriefing of a recorded Math Circle session, and an opportunity to practice facilitation skills via a one--day Julia Robinson Math Festival open to local students. These experiences supported the mentees in learning effective facilitation techniques, sharing resources for finding and developing quality Math Circle lessons, and gaining knowledge about effectively preparing and supporting Math Circle session facilitators. In addition, workshop sessions address logistical issues (e.g. fundraising, recruiting and advertising, administrative essentials and emergency plans); effectively facilitating a meaningful mathematical experience for participants; and content issues (how to develop or identify a rich problem or activity). One participant noted that, "this workshop is a great place to learn what is a math circle and how to start and run one. There is a huge volume of expertise and ideas in this crowd, it is impossible to leave this place without motivation."

One of the most powerful aspects of the workshop is the Julia Robinson Math Festival, co-hosted with the University of Colorado Denver. The 4-hour event brought together 198 students from five middle schools across the greater Denver metro area. Workshop participants found that working with the middle school students was helpful for their development as Math Circle leaders. Students defied their expectations of middle school student behavior with their focus on the problems and enthusiasm. As stated by one participant, "The festival is great for several reasons: we get to see good problems, practice facilitating, talk about important considerations when picking problems and anticipating how to lead them effectively, see and consider logistics, AND it is a great bonding experience for everyone. I think people leave feeling really empowered about doing math circle/outreach activities."

Materials Development

Training Manual. Using funds from our prior year NSA grant, NAMC developed an extensive training manual to support new Math Circle teams. The manual initially included resources on creating initial Math Circle plans, facilitating Math Circle sessions, finding good problems for sessions, and other areas of support related to the administrative components of leading a Math Circle.

Using funds from this year's NSA grant and feedback from the prior year, NAMC enhanced this training manual, including both general enhancements to the prior materials as well as adding supplementary materials on grant writing and training facilitators to lead sessions.

Several different novice Math Circle leaders have mentioned to the NAMC leadership team that these resources were the support that they had been missing, and that they looked forward to using the resources throughout this next year.

To complement the manual, a folder of related documents was collected, reviewed and shared electronically to provide the Novice Math Circle leaders a set of starting materials. After the September workshop, 75% of the participants indicated that these are "just enough" resources to start their program and only 6% described the resources as insufficient. We envision that both the training manual and electronic resources will continue to grow as well as be refined over the next several years as other experienced Math Circle leaders across the country contribute to and support this project.

Webinars. In addition to the training manual, five webinars have been developed for the MC-MAP program:

- *Math Circle Safety & Logistics*
- *Grant Writing*
- *Wrapping up your Math Circle*, including end-of-year tips and evaluation
- *Training Math Circle Facilitators* (new in 2016--2017)
- *Experiences Working with Underserved Youth* (new in 2016--2017)

These are all freely available online to the entire Math Circle community through the NAMC YouTube Channel, with more planned for this coming academic year.

Ongoing Mentorship

While the training materials and workshop provided a strong start to the MC--MAP program, the support to the novice Circle leaders continued throughout the year. Mentors and NAMC leadership maintained regular contact with the Novice Math Circles through the MC--MAP listserv, direct contact between mentors and mentees, some site visits where one a mentor would visit a mentee's Math Circle, informal conference interactions, and the aforementioned periodic training webinars.

Exchange Program

A final component of the program consisted of four Math Circle exchange visits. These programs send a mentor from one Math Circle to present and/or observe another Math Circle. The reports from these visits indicate that the visits meet their goal of providing a forum for an exchange of ideas that enhances the activities of both Math Circles involved. One participant shared, “My visit was a true exchange -- there was much give and take and I think it will benefit the Math Circle communities/programs in both our regions... In particular, I thought a lot about how to broaden our participant base and how best to reach a larger and more diverse group of students.”

Grants to Participating Circles

Each novice and continuing Math Circle received a grant of \$450 (15 total) to assist with operating expenses such as supplies, mathematical manipulatives, books, and mathematical games. Mentors received grants of \$1000 (6 total) to support their Math Circle. While funding is helpful and important, post-workshop and post-program evaluation results indicate that funding alone is insufficient. What the Math Circle leaders need most is the initial training workshop and associated mentoring support.

Program Evaluation

In addition to direct observation and reflection by the program leadership, program participants completed a pre-survey (n=54), a workshop post-survey (n=51), and a program post-survey (n=44).

Feedback from these surveys is highly positive, with the training workshop emerging as clearly the most impactful single component, with all participants stating that overall the workshop was useful to them. In addition, approximately 94% indicated that the Julia Robinson Math Festival was a valuable component of the workshop. In addition, participants indicated that they were excited about meeting other Math Circles professionals, discussing ideas, and building relationships with other participants. When asked to identify the most useful aspect of the workshop, one participant noted the importance of these various forms of materials, responding, “resources, resources, resources! In the form of problems, projects, units, other novice teams, and veteran math circle leaders.”

Two participants nicely summed up their overall thoughts, “our vision and basic structure for our circle changed dramatically after attending this workshop” and “last year’s workshop was great, but this year’s was different and really useful to our team.”

Participants reported increases in their perceived readiness in all areas surveyed - leading sessions, handling logistics, creating a budget, fundraising, and recruiting students. Charts summarizing some data from the report can be found in Appendix B. Here we highlight a few key outcomes, with items are referred to based on a 5 point Likert scale, with 1 being “extremely unprepared” and 5 being “extremely prepared”.

First, there was an increase from approximately 4.3 to 4.6 on how prepared participants felt to lead sessions. Moreover, the percentage of participants who indicated that they felt “extremely prepared” to facilitate sessions increased from 52% on the pre-survey to

66% on the post-survey. Regarding how prepared they felt to handle logistic, scores increased from approximately 4.2 before the workshop to 4.5 afterwards.

Regarding the program as a whole, 43 of the 44 (97%) participants who responded to the post-program survey found the program useful. One 2016-2017 participant said, “I greatly appreciate everything this program has done for our circle. It has supported us in so many ways with resources and funding. I think this program was critical to taking our initial idea of a math club and really making it something that the kids are excited about and feel connected to something bigger than just our circle.”

Another noted, “I was very appreciative to have this program. Not only did it help motivate me to get something started near me, it also helped me feel like I was on track and it helped shed light on things I may have overlooked. The best part of the program was to connect with Circles near me. Being able to communicate with others and observe their Circle was very beneficial.”

When asked about their plans to continue their Math Circle during the 2017-2018 academic year, 13 of the 15 Novice Math Circles indicated that they were extremely likely to continue, with the other two reporting that they were slightly or moderately likely to continue.

In addition, when asked about any major changes or plans for next year, over half of the Novice Math Circles indicated that they plan to expand their program in some way - serve a wider grade range, offer more sessions, offer sessions multiple days of the week, or offer multiple sessions on the same day.

This provides strong evidence to the NAMC leadership team that the MC-MAP program is meeting its goals of helping Math Circles not only successfully start, but continue and expand.

Student Survey Reports to Participating Circles

The MC-MAP program provided a pre- and post-survey to all participating Math Circles serving students at the middle-school level and above. This pilot survey focused on students’ perceptions of their math self-concept, math interest, and math utility, as well as their enjoyment on working on math problems with others, whether or not they’re scared by a challenging math problem, and whether or not they value the procedure in addition to getting the right answer.

Each Math Circle received an individualized report of descriptive statistics based on the data for their Math Circle, which can be used for formative assessment and to support applications for additional funding. A more in-depth statistical analysis of the combined data is ongoing. In addition, NAMC is working to refine the student survey instrument for continued use, as well as to develop additional variants of the instrument.

Future Work

In its first two years, the MC-MAP Program has support over 30 distinct Novice Math Circles. The program will continue to support these groups during the 2017-2018

academic year through financial support, webinars, mentor-mentee interactions, and informal gatherings at major conferences.

NAMC hopes to hold another training workshop in the near future. Plans for a “Circle on the Road” conference, which focuses on professional development across the entirety of Math Circles (i.e., both novice and experienced Math Circle leaders), in August 2018 are in progress.

In addition, NAMC is analyzing existing data from a national survey on Math Circles, working to improve evaluation efforts, and expand its web-based Math Circle resources. The Math Circles community is expanding, and NAMC’s Mentorship and Partnership Program will continue to support its growth.

Appendix A: Summary of MC-MAP 2016-2017 Participants

Novice Math Circles supported by NSA-MEPP in 2016-2017:

- Ithaca Math Circle, Ithaca, NY
- Central Oklahoma Math Circle, Edmond, OK
- Whitewater Math Circle, Whitewater, WI
- Tsehootsooi Intermediate Learning Center Math Circle, Fort Defiance, AZ (Navajo Nation)
- La Ballona Math Circle, Culver City, CA
- Inspired by Math, Emporia, KS
- X Academy, Salinas, CA
- Los Lunas Math Circle, Santa Fe, NM
- Coral Academy of Science, Las Vegas, NV
- Tulsa Girls' Math Circle, Tulsa, OK
- Greater Richmond Math Circle, Richmond, VA
- Maize and Blue Math Circle, Dearborn, MI
- Math Circles Collaborative of Santa Fe, Santa Fe, NM
- Emory Math Circle, Atlanta, GA
- Shippensburg Area Math Circle, Shippensburg, PA

Mentors and Math Circles supported by NSA-MEPP in 2016-2017:

- Rodi Steinig, MS, Talking Stick Math Circle, Philadelphia, PA
- Dr. Maria Droujkova and Dmitri Droujkov, Natural Math Clubs, Cary, NC
- Julia Brodsky, Art of Inquiry, Rockville, MD
- Emily McCullough, MS, San Francisco Math Circle, San Francisco, CA
- Alessandra Pantano, MS, University of California - Irvine Math Circle, Irvine, CA
- Dr. Jane Long, East Texas Math Teachers' Circle, Nacogdoches, TX

Mentors and other Math Circles supported by non-NSA funding:

- Salisbury Central Math Circle, Salisbury, CT
- Luis Munoz Marin Middle School, Bridgeport, CT
- Western Massachusetts Math Circle, Westfield, MA
- Finding Math, New York, NY
- Bard Math Circle, Annandale-on-Hudson, NY
- York International Math Circle, Thornton, CO
- San Francisco Math Circle, San Francisco, CA
- UC Irvine Math Circle and Math CEO, Irvine, CA

Organizers:

- Dr. Diana White, Director of the National Association of Math Circles and Associate Professor at the University of Colorado Denver
- Dr. Brandy Wieggers, Associate Director of the National Association of Math Circles and Assistant Professor at Central Washington University
- Dr. Jane Long, Associate Director of the National Association of Math Circles and Associate Professor at Stephen F. Austin State University

Appendix B: Select Charts from Surveys





