

Final Report  
**National Association Math Circle**  
**H98230-10-1-0260**  
July 23, 2010 to July 22, 2014

## **Final report on NSA-MEPP Grant H98230-10-1-0260**

NSA-MEPP Grant H98230-10-1-0260 was used to fund the Math Circle Grant Program administered by Mathematical Sciences Research Institute (MSRI) in conjunction with the National Association of Math Circles (NAMC) an organization operated by MSRI. The principal aim of the Math Circle Grants Program was to start, sustain, and assess new Math Circles around the country. The Math Circles funded in this way offered extracurricular mathematics education to hundreds of K-12 students and their teachers annually with the ultimate goal of fostering their interest in mathematics and mathematically intensive STEM disciplines.

Math Circles are a form of education enrichment and outreach that bring mathematicians and mathematical scientists into direct contact with pre-college students. Math Teachers Circles are similar in format, but target pre-college teachers of mathematics. These students and students meet with mathematical professionals in an informal setting, after school or on weekends, to work on interesting problems or topics in mathematics. Currently there are over 145 Math Circle programs across the country registered on the website ([www.mathcircles.org](http://www.mathcircles.org)) of the National Association of Math Circles (NAMC).

Twice yearly during the period of the grant, NAMC solicited application for Math Circle Grants. From 2012-2014, the following Math Circle received awards. Each was on the order of \$500-\$2000.

- Acadiana Math Teachers' Circle (Louisiana)
- Art of Inquiry (Maryland)
- Aspen Math Teachers' Circle (Colorado)
- Bard Math Circle (New York)
- Canisius College Math Circle (Buffalo)
- Central Kentucky Math Circles
- Central Nebraska Math Teachers' Circle
- Chippewa Valley Math Teachers' Circle (Michigan)
- Circle Around Math (New Hampshire)
- Claremont Gateway to Exploring Mathematical Sciences
- California State University San Marcos Math Circle
- Denver Math Circle
- East Lansing Math Circle (Michigan)
- East Texas Teachers
- Eastern Kentucky Math Teachers' Circle
- Eugene Math Circle
- Evanston Math Circle (Illinois)
- Fairfax Math Circle (Virginia)
- Fairfield County Math Teachers' Circle (Connecticut)
- Fullerton Math Circle (California)
- Greater Nebraska Math Teachers Circle
- Islander Math Circles (Corpus Christie, TX)

Kansas State University Math Circle  
Kinawa-Chippewa Mathematics Circle (Michigan)  
Kennesaw Math Circle (Georgia)  
Los Angeles Math Circle  
Mankato Area Math Circle (Minnesota)  
Marin Math Circle (California)  
Math Circle at Arizona State University Tempe  
Math Circle at Florida Atlantic University  
Math Circle in the Triangle (North Carolina)  
Math Teachers' Circle of Oklahoma  
Melrose Math Circle (California)  
Metro Atlanta Teachers  
Metroplex Math Circle (Dallas)  
Mid Cities Math Circle (Arlington, TX)  
Mid-Hudson Math Teachers Circle (New York)  
Montana Math Teachers' Circle  
Navajo Nation Math Circle  
New Haven County Math Teachers' Circle (Connecticut)  
New York Math Circle  
Newark Area Math Circle  
North Louisiana Math Teachers' Circle  
Northern Colorado Math Teachers' Circle  
Oregon Museum of Science Math Circle  
Orange County Math Circle  
Oregon Museum of Science and Industry  
Penn State Math Circle  
Philadelphia Area Math Teachers' Circle  
Portland Math Circle (Oregon)  
Prime Factor Math Circle (Seattle)  
Houston Math Circle  
Rockport Elementary Math Circle  
Rocky Mountain Math Circle (Denver)  
Rocky Mountain Math Teachers' Circle (Denver)  
San Benito Count Math Teachers' Circle (California)  
San Diego Math Circle  
San Diego Teachers  
San Francisco Math Circle  
San Joaquin Math Teachers' Circle  
Santa Fe Math Circle (or Teachers  
Seattle Math Teacher Circle  
St Thomas Math Circle

The Math Circle Grants recipients were required to register on [mathcircles.org](http://mathcircles.org) and upload lesson plan content. These lesson plans, in turn, were downloaded and used by other Math Circle leaders.

Recipients were also required to complete a final report. Based on experience, the final reporting requirements were polished. The 2013-14 Grant Reporting template is included below. Sample responses from 2014 (from the Greater Nebraska Math Teachers' Circle, the Navajo Nation Math Circle, and the Mid-Cities Math Circle) are also included below.

One of the most important features of the final iteration of the reporting requirements was the online program post-survey. This is a very significant first step toward gathering data on the impact on Math Circles on the students they served. The preliminary findings of Dr. Brandy Wieggers are appended below.

# National Association of Math Circles Grant Report Template (2013-2014)

**Contact information.** Give the name of your circle, location and frequency of the meetings, and Circle Leaders (names and emails).

**Narrative summary.** Please provide a brief (several paragraph) summary of your circles' activities that addresses each of the following:

(1) What were the goals of the circle (e.g. contest preparation, content enrichment, etc.)? Were those goals achieved? What indicators led you to the conclusion of whether the goal was achieved or not? (Note: We are more interested in honesty than platitudes.)

(2) What were the main highlights and challenges?

(3) Include plans for next year and goals based on this year's experience.

**Mathematics.** After the narrative, list each session from the past year with a brief description (several sentences each) of the content, including the main aims of each session. Please also include the name, affiliation, and position at affiliation of each presenter.

**Budget.** Please provide brief details of your circles' overall budget, including notes on how you spent the Math Circle Grant as well as any other funding sources you have found. For example, were fees charged of participants? One way to report the budget is to provide a table listing line items and cost, and then write a paragraph afterwards addressing the rationale for the line items (when this is not self evident).

**NAMC website activity.** Record links to lesson plans, leader profiles, etc., or other significant contributions to the NAMC website [mathcircles.org](http://mathcircles.org) in the past year. Program Directors should register their circle on the NAMC website, [www.mathcircles.org](http://www.mathcircles.org), update their profile on Math Circle Leaders page (<https://www.mathcircles.org/content/math-circle-leader-profiles>) and contribute at least new one lesson plan to the site.

**Participation.** Enter attendance data in the online form at <https://www.mathcircles.org/content/namc-math-circle-grant-requirements>

**Evaluation.** The participants of the funded Math Circle programs will be required to complete online program post-survey. The surveys will be administered either online or via a one page Math Circle survey. Additional details about this survey will be sent to all programs by March 2014. A summary of the national Math Circle survey results will be sent to the NAMC community in Fall 2014. Questions about the evaluation survey should be directed to Dr. Brandy Wieggers, [brandy@msri.org](mailto:brandy@msri.org)

# National Association of Math Circles Grant Report 2013-2014

## Greater Nebraska Math Teachers Circle

**Name of Circle:** Greater Nebraska Math Teachers Circle (GNMTC)

**Grant Contact Person:** Michelle Homp, University of Nebraska – Lincoln  
Center for Science, Mathematics & Computer Education  
mhomp3@math.unl.edu

**Circle Meeting Locations and Leaders:**

Recall the composition of the GNMTC is unique in that it generally consists of a fall ‘kick-off’ meeting (where the topic for the season is introduced) followed by one or more meetings at each Nebraska location coordinated by a local leader. A list of the locations, dates and leaders is in Table I below. Entries are listed in chronological order.

**Table I**

Meeting Location (attendance)	Meeting Date	Local Leader 1	Local Leader 2	Presentation
Kick-off meeting Kearney, NE (29)	9/29/13	Kathy Neibalski* kathy.niedbalski@kearneyca tholic.org Kearney Catholic High School	Tom Clark Mathematics Graduate Student University of Nebraska	Chomp the Graph: A Mathematical Game of Strategy
Kick-off meeting (Elementary level) Kearney, NE (18)	9/29/13	Cindy Beaman* cbeaman@gips.org Noyce Master Teacher Grand Island Public Schools	Sarah Timmer* shaynes@gips.org Grand Island Public Schools	Where are the numbers? I thought this was Math!
Scottsbluff, NE (11)	10/7/12	Shelby Aaberg* saaberg@sbps.net Noyce Master Teacher Scottsbluff High School	Kathy Vandamme kvandamme@esu13.org Staff developer, ESU 13	Digital Resources
Beatrice, NE (7)	10/23/13	Ed Ankrom* eankrom@bpsnebr.org Thayer Central High School	Deb Bulin deb.bulin@thayercentral.org Thayer Central H.S.	“Math-O-Ween”
Seward, NE (20)	11/7/13	Doug Glasshoff* dglassho@esu7.org East Butler Public Schools	Kyle Royuk kyle.royuk@sewardschools. org Seward High School	Chomp the Graph: A Mathematical Game of Strategy
Grand Island, NE (17)	11/18/13	Amy Nebesniak* nebesniaka2@unk.edu University of Nebraska – Kearney	Jill Edgren* jedgren@esu10.org Noyce Master Teacher Woodriver Public Schools	Chomp the Graph: A Mathematical Game of Strategy
North Platte, NE (9)	11/19/13	Julie Hoaglund* jhoaglund@bradyschools.org Brady Public Schools		Chomp the Graph: A Mathematical Game of Strategy

continued...

Holdrege, NE (0)	2/13/14 canceled	Dan Schaben* daniel.schaben@arapahoew arriors.org Noyce Master Teacher Arapahoe High School		
Falls City, NE (11)	3/20/14	Jason Vitosh* jvitosh@fallscityps.org Noyce Master Teacher Falls City High School		Chomp the Graph: A Mathematical Game of Strategy
Norfolk, NE (0)	4/7/14 canceled	Deb Borgelt debborgelt@npsne.org Norfolk Middle School	Stacey Aldag* stacey@northeast.edu Northeast Community College	
Hebron, NE (6)	4/30/14	Sandi Snyder ssnyder@longhornpower.org Shickley Public Schools	Deb Bulin* deb.bulin@thayercentral.org Thayer Central H.S.	NMR XFI NTMND WQO NFKO? (Can you crack the code?)

\*indicates presenter or co-presenter

## Narrative summary.

### Activities of the GNMTC

The Greater Nebraska Math Teachers Circle 2013/2014 season for secondary teachers began with a “kick-off” meeting in Kearney, NE on September 29. The kick-off event took place the evening prior to the annual Fall Conference of the Nebraska Association of Teachers of Mathematics (NATM). While those teachers who will serve as organizers of a GNMTC meeting in their own communities are especially encouraged to attend the kick-off meeting, any teacher participating in the NATM conference is invited to the circle as well.

The kick-off circle meeting serves several purposes: (1) to introduce the local leaders to the topic/presentation that they will take back to their communities, (2) to recruit additional teachers to lead a circle meeting in their school district or community, and (3) to engage other teachers attending the NATM conference in the Math Teachers Circle experience.

This year there were actually two circle meetings which ran simultaneously: the session for high school teachers mentioned above, and a session with an intended audience of elementary teachers. More information about the elementary session appears in the ‘highlights’ section of this report.

After the kick-off meeting for secondary teachers, the local leaders (and the newly recruited leaders) are provided with lesson plans, a slide presentation, and any other materials needed to lead a GNMTC circle meeting on the same topic in their own communities. Staff at the Center for Science, Mathematics & Computer Education assist local leaders with advertising by creating and distributing electronic fliers and by including information on the GNMTC website (managed by the Center) and in the NebraskaMATH newsletter. Table I indicates the subsequent meetings which were coordinated (two of which were canceled due to low attendance) during the 2013/2014 academic year. Note that local leaders have the option of leading a topic at their site that differs from “Chomp the Graph”, the topic presented at the kick-off meeting.

### Goals of the GNMTC

Math Teachers Circles are designed to bring together teachers of mathematics (especially of grades 6-12) and mathematicians with the goal of discovering and sharing with students the excitement and richness of problem solving in deep yet accessible mathematical topics. More specifically, the main goal of the GNMTC is to bring these enriching networking opportunities to teachers from rural communities, who might otherwise not have access to participation in a teachers circle. A secondary goal is that we hope the experiences at the GNMTC meetings have an impact in teachers' classrooms.

To the degree that it is possible to achieve these goals in one meeting a year per location, we believe we have achieved them. We surmise that the most significant contribution of the GNMTC gatherings is their impact on networking among teachers who are largely otherwise isolated. Evaluations indicate the impact of the GNMTC events on teachers' classroom practice and understanding of mathematics is also positive, though without the benefit of sustained activity is likely to be less significant. Some quotes from teachers that appear on the evaluations from the different locations verify our assertion that all GNMTC goals are met. Three of the questions that were included on the written evaluations conducted at the GNMTC sites are as follows:

- Do you plan to participate in future Math Circle events? Why or why not?
- What did you like/dislike about this activity or past activities?
- What impact, if any, has participation in a Greater Nebraska Math Teacher Circle event had on your teaching or understanding of mathematics?

The following are a sampling of teacher participants' responses to these questions organized around the GNMTC goals.

Comments regarding mathematical enrichment:

*"You can never stop learning."*

*"I liked that this was about strategizing, which is always fun."*

*"I like thinking strategy."*

*"I had a great time learning something new and had great fellowship with other teachers."*

Comments regarding networking:

*"Excellent networking of teachers. This is great for a new to the area teacher."*

*"A good chance to network and talk with more people."*

*"It is a great connection with other area math teachers."*

*"Being a 'newby,' it was great to network with teachers I haven't met before."*

Comments regarding impact in teachers' classrooms:

*"Great ideas have trickled into my teaching. Inspiration has come at needed times."*

*"I am moving toward more project-based learning and this gives me ideas for that."*



*"These are unique strategies to have in the classroom."*

*"It gave me another activity for deeper thinking for my students."*

These comments make it clear that the teachers attending the GNMTC meetings value the experience greatly.

### Highlights

The highlight of the 2013/2014 GNMTC season occurred at the fall kick-off meeting. Organizers of the NATM Fall conference asked that we organize two GNMTC meetings prior to the start of the conference: one for secondary teachers, the other for elementary teachers. NATM conference organizers wished to make a special effort to encourage elementary teachers to attend the conference, which is typically dominated by teachers of secondary mathematics, and hoped that a GNMTC meeting would help them meet this goal. Despite rigorous advertising efforts, prior to the event we had received confirmation of attendance by only eight individuals, including the two presenters. Thus we were pleasantly surprised on the night of the meeting when 16 guests arrived for the elementary session! The secondary teachers happily shared some of their refreshments so everyone was treated to food and fun math.

### Challenges

One of my goals from last year was to encourage more local leaders to host two events during the 2013/2014 GNMTC season, one in the fall and one in the spring. As Table I indicates, I was not successful in achieving this goal. Two of the four meetings scheduled to take place in the spring were canceled due to lack of participant response, while none of the fall events were canceled. Several of the local leaders have indicated that scheduling an event in the fall works better for GNMTC meetings in smaller communities because teachers seem to be less busy in the fall. In particular, meetings in early November work especially well since this time frame corresponds with a brief reprieve between fall and winter sports seasons. While the notion of having more regularly scheduled events at each location has much appeal (and fits the more standard model of math teachers circles), it has become clear that the realities of teaching in rural communities make a GNMTC meeting more likely to be successful if it occurs in the fall. Though I will not discourage leaders from planning an event in the spring, in the future I will caution them about this trend. Regardless of whether one or two events occur, I firmly believe that coordinating only one GNMTC meeting in these rural communities is well worth the effort and offers teachers who would otherwise be isolated a valuable opportunity to network with peers.

### Plans for the 2014/2015 GNMTC season

As mentioned in the previous paragraph, although I will not discourage local leaders from hosting a spring GNMTC event, next year I plan to focus my efforts on encouraging more meetings in the fall.

Additional plans for next year include working with organizers of a math teachers circle that had been convening in Kearney, NE, from 2012 – 2014. Under the

leadership of Pari Ford (University of Nebraska at Kearney), the Central Nebraska Math Teachers Circle had been convening approximately four times per academic year. Although Kearney is the fifth largest city in Nebraska (with population 31,000), the average attendance at these meetings was roughly seven (according to 2012/2014 numbers). At the Fall kick-off meeting, Ford approached me about the possibility of merging with the GNMTC. Additionally, a high school teacher who attended the fall kick-off meeting, expressed interest in organizing a GNMTC event. Although I put these two individuals in contact with one another hoping they would work together to continue the Central Nebraska MTC, I neglected to take further action toward this cause. I was a bit reluctant to absorb the Central Nebraska circle into the GNMTC for the following reasons:

- The GNMTC budget is not sufficient to absorb the additional expenses that would be incurred supporting the Central Nebraska circle, especially if they wished to continue meeting on a regular basis.
- The fall kick-off meeting takes place in Kearney; thus teachers from this area already have an opportunity to attend a GNMTC event and the majority of the budget (see below) is used to fund it.
- Since one of the goals of the GNMTC is to provide networking opportunities to teachers from rural areas, it seems unjust to allot further funds to provide multiple opportunities for teachers in Kearney to gather when these teachers are far less likely to experience the isolation that is prevalent in the smaller communities.

Regardless, I do wish to be supportive of the Central Nebraska Math Teachers Circle, and thus my plans for 2014/2015 include further communication with this circle's organizers to learn more about their goals for the continuation of the Central Nebraska Math Teachers Circle and (possibly) to encourage them to apply for their own seed or continuation grant.

Finally, whether or not it is requested by the NATM board, I very much hope to continue offering an elementary GNMTC session at their fall conference.

### **Mathematics.**

Each of the GNMTC session titles and descriptions are below. Unless otherwise indicated, presentations are intended for an audience of teachers of grades 6 – 12. Presenters and affiliations are indicated in Table I above.

#### Chomp the Graph: A mathematical game of strategy

Chomp the Graph is a game of strategy in which two players take turns removing vertices and edges from graphs. Players move in turn rather than simultaneously and each player has complete information about the state of the game while making a move. The winner of the game is the one who removes the last vertex, leaving the loser with nothing to remove. Learn about connections between the attributes of a graph and a winning strategy.

### Digital Resources: Incorporating Digital Videos and Images into Your Math Instruction, for K-12 Teachers

Teachers encounter interesting videos and images everyday on websites, social media, and in print media. When encountering an interesting problem or idea, a teacher may wish to use the video or image. However, the teacher may not know where exactly the video or image could fit into his or her curriculum. The instructor will provide guidance and facilitate participants accumulating digital media for direct classroom use. The instructor will model how to transition to problem-based learning using digital media.

### Math-O-Ween

Come explore some interesting ways to incorporate fun Halloween activities into your math classroom to introduce, teach or reinforce key concepts. Topics include: line of best fit, differentiation, transformations, probability and more.

### Where are the Numbers? I thought this was math! (Teachers of grades K-5)

Learn and discuss effective strategies for engaging elementary students in problem solving. One of these strategies is to hide the numbers in the statement of a word problem when it is first introduced to engage children in thinking about the context rather than 'grabbing the numbers' and quickly choosing an (sometimes arbitrary) operation.

### NMR XFI NTMND WQO NFKO? (I.e. Can you crack the code?)

Help bring some reasoning and sense-making into your classroom by using Cryptology and codes. We will look at some history of Cryptology and some different types of codes to use in your classroom.

## **Budget.**

A spreadsheet of the 2013-2014 GNMTC expenses is attached.

The vast majority of the GNMTC budget, 92.5% of it, covers food expenses at the different events. Notice also that 65% of the total budget covered expenses for the two fall kick-off meetings, despite the fact that NATM provided a total of \$200 in support toward the costs. The kick-off meetings are especially important to the success of the GNMTC as the topic for secondary teachers for the fall season is introduced at this time. It is also important to Nebraska teachers in that this gathering is the only circle meeting for several the teachers in attendance and is also the event that might inspire other teachers to lead their own MTC meeting in their home communities.

Advertising, operational and food costs which exceed the funds granted by the MSRI are covered by the Center for Science, Mathematics and Computer Education. Twelve of the local organizers donated their time for logistical preparations and/or for leading presentations. Five of the local leaders are part of a Noyce Master Teacher fellows program and receive a general stipend through a Noyce grant in

exchange for providing general leadership within their schools/districts. The graduate student in mathematics who assisted with the kick-off circle meeting was hired by the Center to provide support for the local leader, Kathy Neidbalski.

Additionally, because the kick-off meeting is tied to the Nebraska Association of Teachers of Mathematics (NATM) annual conference, local leaders find their own support for travel expenses from their schools or other sources. In addition, teacher participants and local leaders pay their own travel costs to attend remaining GNMTC meetings. We anticipate that travel costs for attending the kick-off meeting will continue to be minimal; however if it is not provided by a local leader's school/district, we hope to offer travel support if any funds in the GNMTC budget were to go unused.

### **NAMC website activity.**

The "Chomp the Graph" lesson is available on the NAMC website at <http://www.mathcircles.org/node/1212>

The GNMTC is registered on the NAMC website at <https://www.mathcircles.org/content/greater-nebraska-math-teachers-circle>

The official GNMTC website is located at <http://scimath.unl.edu/gnmtc/>

I have updated my leader profile information. I received the following acknowledgement about the GNMTC leader profile information (although I was unable to locate this information on the NAMCE website):

*On Mon, May 5, 2014 at 11:55 AM, <[nmc@mathcircles.org](mailto:nmc@mathcircles.org)> wrote:  
Your Wiki Page entry entitled "Math Circle Leader Profile" has been created by our content creator!  
Regards,  
The National Association of Math Circles team*

### **Evaluation.**

The stipulations for reporting about circle evaluations are as follows:

*The participants of the funded Math Circle programs will be required to complete online program post-survey. The surveys will be administered either online or via a one page Math Circle survey. Additional details about this survey will be sent to all programs by March 2014. A summary of the national Math Circle survey results will be sent to the NAMC community in Fall 2014. Questions about the evaluation survey should be directed to Dr. Brandy Wieggers, [brandy@msri.org](mailto:brandy@msri.org)*

I sent an email to Brandi Wieggers on May 9, 2014 to inquire about the online program post-survey as I did not receive any information about this. I also asked for her recommendation on how to report about the GNMTC evaluations. Since I did not receive a response, and since it is unlikely that the unique composition of the GNMTC would result in meaningful data if collected online at this late date, I will simply summarize the results of the written evaluations conducted at the GNMTC sites.

Written evaluations were conducted at a majority of the GNMTC meetings (unfortunately not every local leader remembered to administer them). This summary reports on 61 evaluations from six locations.

Some summary points are below:

- Of the 61 respondents, 34 were attending a circle meeting for the first time.
- All 61 respondents indicated that they plan to attend future circle meetings. They enjoyed the fresh ideas, thought-provoking activities, great company and networking.
- Reasons for why participants chose to attend were largely due to ‘word of mouth’; 37 indicated they heard about the event from colleagues, 18 came solely as the result of seeing an advertisement, and for 41 respondents the motivation was because they simply love math. (Note: respondents could select more than one reason.) Others listed getting emails from their ESU or SOAR program, heard about it at a monthly curriculum meeting, or simply wanted to enjoy a free supper with peers.
- Comments about what teachers would like to see continue were largely equivalent to ‘more of the same’ and games for their classrooms. The most popular requests were: three requested topics related to geometry, three wished for more discussion about using apps in the classroom, three wished for more on number sense, and three asked for topics related to problem solving.

Responses about the benefits of the circle focused on the goals of the GNMTC and comments can be found in the narrative summary section of this report.

## Navajo Nation Math Circle

Directors: Dave Auckly [dav@math.ksu.edu](mailto:dav@math.ksu.edu), Tatiana Shubin [tatiana.shubin@sjsu.edu](mailto:tatiana.shubin@sjsu.edu), Henry Fowler [henry\\_hf@hotmail.com](mailto:henry_hf@hotmail.com), Bob Klein [kleinr@ohio.edu](mailto:kleinr@ohio.edu).

2013-2014 Navajo Math Circles Grant											
Date(s)	Activity Name	Brief description	Activity location	Faculty involved	# Students	# Boys	# Girls	Name of School(s)	# Teachers	# Pre-service teachers	# Volunteers (students, community members, parents, etc.)
12/7/2013	GCD MC and CCSSM	Water Jug Problem Counting the number of steps in the Euclidean Algorithm	Dine	Blake Thornton Maggie Cummings	5				25		
12/6/2013	Hat problems RSA guessing Collatz Sum Free Partition Acute triangles	see hats on NAMC and rest on mathpickle	Thoreau Middle School,	Blake Thornton	25			Thoreau Middle School,	1		
12/9/2013	Hat problems RSA guessing Collatz Sum Free Partition Acute triangles	see hats on NAMC and rest on mathpickle	Rough Rock	Blake Thornton	119			Rough Rock	1		

12/10/2013	Hat problems RSA guessing Collatz Sum Free Partitions Acute triangles	see hats on NAMC and rest on mathpickle	Round rock MS	Blake Thornton	60			round rock	1		
12/11/2013	Hat problems RSA guessing Collatz Sum Free Partitions Acute triangles	see hats on NAMC and rest on mathpickle	St Michael	Blake Thornton	108			St Michael	1		
3/27/2014	Math Circle at Navajo Technical University	Inscribed Square Puzzles from Math Pickle. Nim Games.	Navajo Technical University	Tatiana Shubin	0	0	0	Navajo Technical University			~10
3/28/2014	Math Circle: Chromatic Numbers	1.75-hour Math Circle organized by Corvina Etsitty. Students signed up to attend during the morning and were released from regular classes. Students tried a variety of line and plane coloring challenges	Many Farms High School	Tatiana Shubin	~15	?	?	Many Farms High School	1	1	0

		that highlight the betweenness property of points on a line and which lead to an open question about the chromatic number for the plane.									
3/28/2014	Math Circle: Digits Fidgets	1.75-hour Math Circle organized by Corvina Etsitty. Students signed up to attend during the morning and were released from regular classes. During a lesson inspired by Sam Vandervelde's Digits Fidgets activity, students explored patterns in decimal representations of a variety of rational numbers. Students	Many Farms High School	Amanda Serenev	~15	?	?	Many Farms High School	1	1	0



		created their own conjectures and investigated their questions.									
3/29/2014	Teachers' Math Circle: Fractions, Decimals, Ratios, Percents, Proportions	During this 1.5-hour Math Circle, teachers explored a wide range of questions relating to fractions, decimals, ratios, percents, and proportions. Discussions revealed how many math topics that are commonly taught as discrete subjects, are united by conceptual approaches to these topics.	Dine' College	Tatiana Shubin	0	0	0	Several elementary, middle, and high schools were represented.	~27	~3	5
3/29/2014	Teachers' Math Circle: Julia Robinson preview	During this 1-hour session, teachers tried some of the proposed Julia Robinson	Dine' College	Amanda Serenev; Tatiana Shubin	0	0	0	Several elementary, middle, and high schools were represented.	~27	~3	5

		Challenges and learned about plans for the upcoming festival.									
3/29/2014	Teachers' Math Circle: Cultural Connections to STEM Learning	During this 1.5-hour session, teachers ate lunch and discussed cultural connections to STEM topics. A young singer also performed for the group.	Dine' College	Henry Fowler	0	0	0	Several elementary, middle, and high schools were represented.	~27	~3	5
3/29/2014	Teachers' Math Circle: Teaching the Common Core State Standards -- What's Next? Using Patterns To Explore Functions.	During this 1.5-hour session, we explored how geometric designs, game strategies, and real-world scenarios can provide a framework for learning about linear and non-linear functions. During this session, we used tables, graphs, equations,	Dine' College	Amanda Serenity	0	0	0	Several elementary, middle, and high schools were represented.	~27	~3	5

		and contexts to explore patterns of growth and the tell-tale signs of different kinds of functions.									
4/29/2014	Julia Robinson Festival		Dine	Josh Zucker	202						

Math circles are a very effective way to build communities to encourage people to explore mathematics and share the joy of mathematics with others. The goal of the Navajo Nation Math Circle Project (NNMCP) is to develop and demonstrate the math circle concept in the Native American community in order to attract more Native Americans into STEM fields, specifically the field of mathematics.

The NNMCP includes three major components: after school programs at a number of schools on the reservation, teacher development programs, and a two-week summer program. The program is co-directed by Tatiana Shubin (San Jose State University), Henry Fowler (Diné College), Robert Klein (Ohio University) and David Auckly (Kansas State University). Tatiana spent the Fall of 2012 on the reservation, where she launched five math circles at four schools: Tsehootsoo Middle School, Chinle High School, St. Michael Indian School (SMIS) Middle School and High School and Many Farms High School. Sr Joan of Arc of St Michael’s Indian School started leading after-school math circle sessions in the Spring of 2013 In order to sustain these circles the program directors are arranging a number of teacher development programs, that will help teachers understand this method of mathematical interaction. The team also provides scripts and activities that the teachers can use. We are very hopeful that we will be able to recruit more local teachers to lead such programs. School year activities for the students included a logo contest, and problem of the week contests. Over six hundred middle and high school students took part in these after-school mathematics activities.

The first teacher workshop took place in December 2012 at Diné College. Tatiana Shubin led two two-hour sessions. The second teacher workshop took place in April. Amanda Serenevy (Executive Director of the Riverband Community Math Center, IN) ran several sessions related to mathematical problem solving, and the Common Core State Standards in Mathematics. The third teacher workshop took place in July, with sessions led by Dave Auckly, Tatiana Shubin, and Amanda Serenevy. It included Teacher programs (for current as well as future teachers)

which are critical to capacity-building, to support the teachers' abilities to facilitate open-ended problem-solving and to increase the mathematical knowledge for teachers. Because the new Common Core Standards for Mathematics emphasize mathematical practices of reasoning and problem solving, which are also practices supported by math circles, hosting both teacher math circles and teacher Common Core Workshops in conjunction works well. The new standards give us a way to change the way people approach mathematics. To take advantage of this, the NNMC also included a program for pre-service teachers at Diné College. Around 90 teachers have participated in program workshops.

The two-week summer school served 26 mainly high school students from across the Navajo Nation. Each day students were transported from across the reservation to Diné College. After breakfast, students would work on problems, play mathematical games, and try various puzzles (Three sons and two fathers are each to be given exactly one of three feathers. How is this possible?) The students then split into two groups for a mathematical exploration led by one of the visiting mathematicians. These mathematicians included Dave Auckly, Matthias Kawski (Arizona State University), Amanda Serenevy, Tatiana Shubin, and Nandor Sieben (Northern Arizona University). The morning mathematical session would be followed by a hot lunch, then an educational/cultural activity such as traditional Navajo games, foods and cooking, or constructing solar ovens. (Natural pockets in canyons have been used as solar ovens for centuries.) There was also significant time for non-mathematical fun and games. Henry Fowler, Forrest Randall, Kamile White, Edison Leonard, Dawnlei Ben, and Barsine Benally were local educators who helped run the math camp. One activity they brought taught the Navajo names for two and three-dimensional shapes by having groups of four students make the shapes with their bodies. The team also brought role models to the camp. Robert Megginson is a mathematics professor at the University of Michigan. He is also of the Oglala Sioux tribe. He gave a presentation about the use of mathematics to understand and address climate change. He also pointed out that indigenous peoples have a unique perspective on climate change and places to look for further evidence and methods for adaptation via their cultural traditions. John Herrington of the Chickasaw was the first Native American in Space. He described his path to becoming an Astronaut, and encouraged the students to be confident and trust people who believe in them.

The program certainly is generating enthusiasm from the participants. One of the youngest campers, Ellisan Cly, asked Nandor, if she could skip lunch to keep working on the activity that he introduced. Another student, Albert, is studying with a math teacher and a practicing medicine man, Damien Jones, to be a medicine man. One afternoon, he gathered a group of students to tell them about the mathematics that he just learned. Most of the students who were at the math camp this summer have agreed that it's been a wonderful experience, that they would recommend to their friends. They hope to come back next year.

The summer 2014 math camp will take place July 14 – 25, 2014.

New lesson plan from Navajo Nation:

<https://www.mathcircles.org/node/1104>

# National Association of Math Circles 2013 – 14 Grant Report Form

## Contact information

Name of circle: Mid-Cities Math Circle  
Location of circle meetings: University of Texas at Arlington, Arlington, TX  
Frequency of meetings: every week in Fall 2013; every other week in Spring 2014  
Circle leaders: Dimitar Grantcharov, grandim@uta.edu

## Narative summary

- (1) Goals of the circle. Our main goals are to attract students' attention to mathematics and motivate them to excel in the subject; as well as to help those who are already attracted and need to develop their talent and skills. One particular goal of our math circle is to prepare the students for mathematical contests. The main body of the math circle consists of very talented middle and high-school students from the Dallas Fort Worth area and the math circle is the place where they come to solve challenging problems. Lectures on various topics are presented by distinguished mathematicians and these lectures are normally the highlights of the math circle. The main goal to prepare the participants for competitions was definitely achieved – we have one USAMO participant, and about 6 AIME participants.
- (2) Main highlights and challenges. We had several guest speakers whose lectures were outstanding. Each of these lectures can be considered as a highlight of the math circle. The lecture that probably attracted most attention was the one delivered by Professor Frank Sottile from Texas A&M who presented explicitly how the hyperbolic geometry works by cutting and gluing paper.

The biggest challenge was to run the math circle in Spring 2014 while I was on a faculty development leave (sabbatical) and had intense travel schedule. Mr. John Cocharo from Oakridge High School did great job by leading the math circle in February, March and April. It was a bit difficult year as there were no student assistants that volunteer to help with the math circle.

- (3) Plans for the next year. The main challenge in near future will be to attract new participants. This year, eight of our math circle participants are going to college. In order to meet this new challenge, the math circle will need to change its level from advanced to intermediate. My plan is to attract kids from lower grades (grades 5 and 6). Two of the graduate students I am currently advising, Andrew Cavaness and John Griffis, expressed interest in helping with the math next year. Such help would allow us to spend more time on recruiting, and on maintaining the math circle web page, blog and facebook page.

## Mathematics

Below you can find the list of sessions taught during the past academic year along with a brief description of the content.

### *Fall 2013*

September 10            Quadratic Functions and Recursion (by D. Grantcharov)

The topics discussed were: Vieta's formulas, symmetric polynomials of roots of quadratic function, word problem involving recursive sequences, solving recursive equations involving one or two sequences, tiling of rectangles.

September 17            Triangle Inequality (by Dominic Yurk, student at California Institute of Technology, former MCMC participant)

Two versions of the triangle inequality: algebraic and geometric. The geometric triangle inequality was given in terms of complex numbers. Applications in complex analysis were discussed. The lecture ended with an application of Rouché's theorem.

September 24            Polynomials (by D. Grantcharov)

This was a natural continuation of the lecture given on September 10. Vieta's formulas and symmetric functions of the roots of arbitrary polynomials were discussed. Polynomial equations and nontrivial substitutions that lead to solutions of several challenging problems were solved.

October 1                Polynomials II (by D. Grantcharov)

This was a continuation of the previous lecture. Complex numbers, trigonometric substitutions and polynomial inequalities were discussed. IMO level problems were solved at the end.

October 8                Invariants (by D. Grantcharov)

Word Problems that involved invariants and coloring were solved. For example – placing figures on a chessboard, handshake problems, ordering numbers on a circle, etc.

October 15                Invariants II (by D. Grantcharov)

This was a continuation of the previous lecture. Number theory and convex geometry problems were discussed. Geometric transformations were involved in several problems.

October 22                Conjugate Numbers (by D. Grantcharov)

Due to popular demand we discussed variations of conjugations – the “regular” complex conjugation and the conjugation of expressions involving radicals. Inequalities and number theory problems were solved.

October 29                    Coloring (by D. Grantcharov)  
Problems that involve coloring and tiling of figures in the plane and the space were discussed. Most of the problems involved dominos, tetrominos, etc. Some interesting graph theory problems were solved (connecting cities with roads).

November 4                    ARML problems (by John Cocharo, Oakridge High School)  
Selected problems from the last ARML competition were solved. The students were separated into several teams and competed with each other.

November 11                    Coloring II (by D. Grantcharov)  
This was a continuation of the lecture delivered on October 29. Homework problems were discussed and more challenging graph theory problems were solved.

November 19                    Hyperbolic Footballs (by Frank Sottile, Professor, Texas A&M University)  
Axioms of hyperbolic geometry were presented through explicit examples of hyperbolic footballs. The footballs were created by the math circle participants themselves by cutting and gluing paper.

November 26                    No Math Circle (Thanksgiving)

December 3                    Cryptology (by Michaela Vancliff, Professor, University of Texas at Arlington)  
Problems from basic cryptology were discussed using classical number theory (congruences). The RSA algorithm was the main topic in this lecture.

### *Spring 2014*

January 23                    Spider and fly (by Cornelius Pillen, Director of Mobile Math Circle, Professor, University of South Alabama)  
Classical problems about a spider chasing a fly on a rectangular grid were discussed. The difficulty of the problems gradually increased and at the end the “zig-zag spider” and the “rational spider” questions were answered.

February 4                    AMC problems (by John Cocharo, Oakridge High School)  
AMC8 and AMC10 problems of moderate difficulty were discussed. The problems were mostly algebraic and combinatorial.

February 18                    AMC problems II (by John Cocharo, Oakridge High School)  
More challenging AMC8, AMC10, and AMC12 problems were solved. The problems were mostly algebraic and geometric.

March 4                        AMC problems III (by John Cocharo, Oakridge High School)  
Problems among the last five AMC10 and AMC12 problems were solved.

March 18                        AIME preparation session (by John Cocharo, Oakridge High School)  
Old AIME problems were solved.

April 1                      AIME preparation session II (by John Cocharo, Oakridge High School)

More challenging old AIME problems were solved. Different strategies how to succeed on the competition were discussed.

April 15                      Mathcounts (by John Cocharo, Oakridge High School)

A relaxing session devoted to problems from old Mathcounts competitions.

April 29                      Mathcounts II (by John Cocharo, Oakridge High School)

Another session devoted on Mathcounts.

### **Budget**

Below you can find details about the expenses related to this grant. An itemized Excel file and a file with the scanned receipts are attached separately.

1. *Pizzas.* We serve pizzas and drinks during every math circle meeting. We order 4, 5 or 6 pizzas from Dominos.
2. *Books.* We purchased a set of books that will enrich the math circle library. Some books will be used as awards for the winners of the UTA Math competition in March 2015.
3. *Travel.* The director of Mid-Cities Math Circle visited Berkeley Math Circle in March 2014. His air fare was covered by the grant.

The students did not pay a participation fee during the 2013-2014 school year. The two fall 2013 guest speakers (M. Vancliff and F. Sottile) politely declined the honoraria for their talks to save money of the math circle. The saved funds were used to buy books.

### **NAMC website activity**

Below links to some of the lesson plans uploaded to the NAMC website (mathcircles.org) are listed.

<http://www.mathcircles.org/node/1222>

<http://www.mathcircles.org/node/1087>

<http://www.mathcircles.org/node/818>

### **Participation**

Below you can find a list of schools represented at our math circle.

Colleyville Heritage High School

Immaculate Conception School

Martin High School

McLean High School

Oakridge School

Paschal High School

(Note: there are two home school students)



Detailed information about the participants was submitted with the online form at

<https://www.mathcircles.org/content/namc-math-circle-grant-requirements>

# National Association Math Circle (NAMC) 2014 Post-Survey Summary

*Math Circle is awesome and fun. I learned a lot from Math Circle. - NAMC Student*

In 2014 Dr. Brandy Wieggers completed the first national survey of the mathematical attitudes of Math Circle participants. This initial work was based from successful work evaluating the impact of the San Francisco Math Circle program on the participating students when compared to non-Math Circle students. Overall the results of the national Math Circle survey demonstrate that the participants of Math Circles have the strongest mathematical attitudes of any so far surveyed by the evaluator.

## Evaluation Design

This evaluation is based off of previous work done at the San Francisco Math Circle (SFMC). SFMC is a program designed to increase the quality and quantity of students who become mathematics educators and researchers, or who simply love and use mathematics in their studies, work and daily activities. The SF program is unique as an after-school program because it uses teachers to transport and encourage students to attend. In addition the program reaches out to these attending teachers, providing professional development and a supportive pedagogical environment. In turn, we believe that teacher support provides opportunities to draw students to the program who are economically disadvantaged and who might not otherwise not attend. This is different from our understanding of many other Math Circle programs which rely on parental encouragement of student attendance.

The objective at San Francisco Math Circle is to develop a *Safe Mathematical Community* for individual students and teachers involved in the program (i.e. a community where participation has little expected emotional cost) which will result in:

1. increased individual mathematical competency;
2. increased individual problem solving competency;
3. individual students choosing to do mathematical activities;
4. individuals students choosing to explore harder mathematical tasks;
5. increased persistence on mathematical tasks;
6. an increased understanding of what math is.

These goals are similar to those expressed by other Math Circle leaders for their programs, thus the SFMC evaluation approach was a natural connection to extend for a national survey. In the future, it would be very informative to work with Math Circle leaders to more clearly define their individual focus on these goals. Dr. Brandy Wieggers and Dr. Diana White are currently grant writing to find financial support to more clearly define the Math Circle's national focus for these goals.

## Survey Design

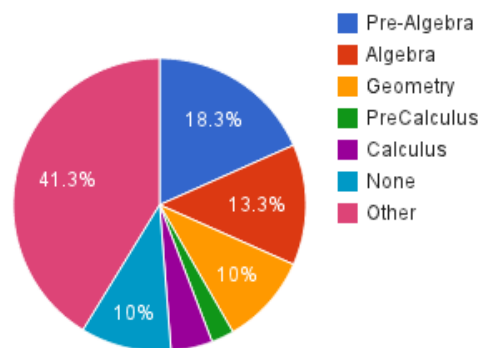
*People are most likely to do things at which they think they can succeed and that have high value for them. - [2]*

In 2010, at the request of the funders, SFMC designed an evaluation process to make a rigorous attempt at evaluating the program's impact on the participating students. The key component was pre and post survey of program participants to understand how the SFMC goals were (or weren't) being met. Please note: The need to first define a program's goal, prior to developing the evaluation, was a key aspect in the survey design. Many of us may not have had experience in math education and when attempting to design evaluation of our programs it may feel more natural to first define the questions, send them to the students, and then decide what the student responses' can be interpreted. It is crucial to effective mathematical education research to do it the other way, first define the goals of the program and then find evaluation tools that measure the impact of the program on these goals. The evaluation tool that was created for the SFMC was designed as a rigorous Math Circle participant survey and the questions were

designed based on the *Expectancy-value theory* of mathematical education. The *Expectancy-value theory* argues that the goals, most especially, “*individuals’ choice, persistence, and performance can be explained by their beliefs about how well they will do on the activity and the extent to which they value the activity [1, 3, 5, 6]*” [7]. Researchers of this area have developed a model for achievement motivation focused on using *task value* and *expectation of success* to measure achievement/ motivation of goals similar to those we’ve created for Math Circle.

Most importantly, a literature review has revealed a set of questions related to assessment of a program’s impact on expectancy-values. These questions have been given to middle school aged school children and have been shown to have 15 years of stable measurement of the task values and expectations of success in relation to their measurement of our goals. Dr. Brandy Wieggers and Dr. Yvonne Lai prepared a survey of these questions. The initial survey was given Spring 2010 to SFMC students as well as other non-Math Circle students that teachers in the Math Circle work with (providing a control group of Math Circle vs non Math Circle students). The survey design was then modified based off the feedback from the students about what questions they understood and what questions they did not understand. This revision process resulted in the 2014 post-survey that was used this Spring for NAMC. Another revision process is required based off the Spring 2014 results, as some questions that are relevant to San Francisco don’t work for the national survey. An example is asking students to rank their feelings on these two questions “*I enjoy studying math in my school math class*” and “*I would rather be in my math class than my other classes.*” These two questions are relevant for a school-based Math Circle program but many of our Math Circles work with home-school students and other students on specialized individualized tracks, see the graph below of the respondents’ current math classes. Many of the students in the national survey struggled to address these questions and in turn the survey results were not representative of their mathematical attitudes.

**What Math Class are you Taking?**



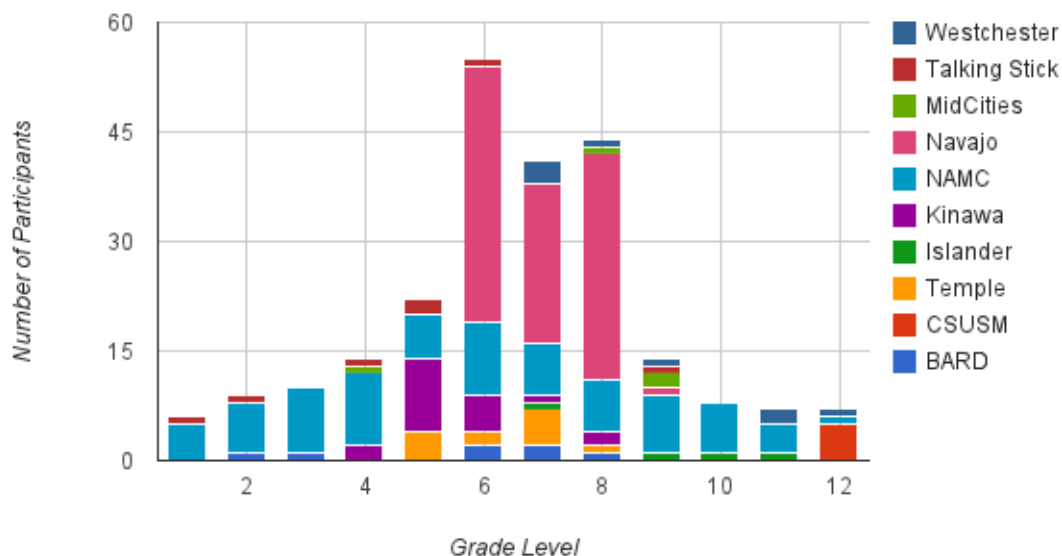
## 2014 Post-Program NAMC Survey Participants

The post-program survey was completed by 240 students across the country. All of the students who participated attended Math Circles that had received a MSRI NAMC Math Circle Grant.

The participating Circles included:

- Bard Math Circle (New York, Elementary & Middle School Students)
- CSUSM -California State University, San Marcos Math Circle (California, High School Students)
- Islander Math Circles (Texas, Middle & High School Students)
- Kinawa-Chippewa Mathematics Circle (Michigan, Middle School Students)
- Los Angeles Math Circle (California, Elementary, Middle, & High School Students)
- Math Circle at FAU- Florida Atlantic University, (Florida, Middle School Students)
- Mid-Cities Math Circle (Texas, Middle & High School Students)
- Navajo Nation Math Circle ( Arizona, Middle & High School Students)
- Talking Stick Math Circle (Pennsylvania, Elementary, Middle, & High School Students)
- Temple University Mathematics Circle (Pennsylvania, Middle School Students)
- Westchester Area Math Circle (New York, High School Students)

## Grade Levels of SFMC Survey Participants



Looking more closely at the grade levels of participating students we can see many of the Circles that were surveyed contain students from 1st through 12th grade. This presented the first lesson learned from the Math Circle Spring 2014 post-evaluation. The original tool was designed for middle school students and above. Responses from many students younger than this were inputted or heavily influenced by parents and in turn don't often provide a representative view by the student themselves. An example statement was, "*Honestly, I think I am too young to think about that yet*" when asked the question, "If you were in college now, what major would you choose?". Anticipated responses for this age range are more of the form "*I don't know yet*" or "*be a ballerina*". Future evaluation design needs to account for this, most likely with this evaluation tool requiring students to be 13 years and older. A different evaluation tool, most likely including parent feedback, will need to be designed for younger students.

The final summary of the NAMC Spring 2014 post-program evaluation removed those younger students to focus on the responses from the 179 students 6th grade and above. The results of the NAMC Spring 2014 post-program survey are compared to the results of the post-program survey given in Spring 2014 to the SFMC program, which had both Math Circle and non-Math Circle students who took the survey. Thus, the evaluator was able to compare middle/high school Math Circle participants' values to those of non-Math Circle participants' responses.

## Survey Questions and Results

### Expectancy-Value Theory

The survey tool has questions focused on both task value and expectations of success. To support your understanding of this we will provide definitions for these tasks, provide sample task-value evaluative questions from the survey, and provide feedback on the responses that were recorded.

### Task Value

Students who believe that mathematics is important to them personally and that mathematics has some usefulness to them in terms of their future career goals have high task value beliefs. More specifically the task value can be separated into four values areas: intrinsic or interest value, utility value, attainment value, and cost [3, 4, 7]. We examine each of these categories separately below.

### **Intrinsic or Interest Task Value**

Interest is the enjoyment the individual gets from performing the task, or the subjective interest they have in the subject. Example questions include:

- I enjoy the subject of math? [4]
- I enjoy studying math in my school math class?

Students in Math Circle, have the highest interest in mathematics and enjoy the subject of mathematics. The NAMC post-survey results had even higher values than the SFMC post-survey which is considerably higher than the interest results of non-Math Circle participating students.

Surprisingly, one issue that happens with the SFMC survey is a consistent theme of frustration throughout the responses that the students expressed about their classroom mathematics after having been involved in Math Circle. It is surprisingly not a theme noted by the evaluator for the students that responded with the national survey although it should be noted that more of those students are involved in non-traditional mathematical courses compared to the NAMC survey participants, several of which are taking classes including calculus and graduate level special topics courses.

### **Utility Task Value**

Utility is how the task relates to future goals, and can be seen as capturing more extrinsic reasons for doing the task (e.g., valuing an organic chemistry class because of future plans to be a doctor). Example questions include:

- I need to have good mathematics problem-solving skills to be successful in the future?
- Math will be useful for me later in life? [4]

Once again the students in the national survey had even high utility value than the SFMC Math Circle students which is higher than the utility value of non-Math Circle students. This is exciting to note because the SFMC surveys has shown a longer-term impact of Math Circle students' utility value. Students who come into the SF Math Circle in the Fall returned with the understanding of the Utility of mathematics. This supports that Math Circle is having a lasting impact on the mathematical attitudes of the students involved. The continued study of the national programs will look for similar trends using pre and post survey formats.

### **Attainment Task Value**

Attainment is the importance to the self of doing well on a task. It is linked with identity and confirming or disconfirming salient aspects of the self, and represents more intrinsic reasons, as the task is valued in itself, not because it will get the individual some other valued goal. Example questions include:

- In addition to getting the right answer in mathematics, it is important to understand why the answer is correct?
- Compared to most of your other activities, how important is it for you to be good at math? (not at all important/ very important)[7]

The trend continued with attainment value, the students who participated in the national survey had higher attainment values than the post-survey Math and non-Math Circle participants of the SFMC.

### **Cost Task Value**

Cost refers to the accumulated negative aspects of engaging in the task, including anticipated emotional states (performance anxiety, fear of failure), and the amount of effort required to succeed at the task. Example questions include:

- Hard math problems scare me?
- I would rather be in my math class than my other classes?

The national Math Circle students surveys had smaller scores for the Cost task value when compared to the SFMC students. A smaller score can be interpreted that students had a more negative impact from their participation in math over the course of the year. This may be a quirk of the survey or maybe something of concern. With improved survey instruments the evaluator will be able to provide national Math Circle leaders additional details to review this concern.

## Expectation of success

*Math circle was a great opportunity to better my problem solving skills. Rather than having a linear approach to solving a problem, I am now able to approach any problem multiple ways to solve it.* - NAMC Student

Eccles et al. (1983) defined and measured expectancies for success as childrens beliefs about how well they will do on upcoming tasks, either in the immediate or long-term future [3]. A series of questions shown to measure personal expectations of mathematical competency include:

- Some kids are better in one subject than in another. For example, you might be better in math than in reading. Compared to most of your other school subjects, how good are you in math?
- How good in math are you? (not at all good/ very good) [7]

Overall the non-Math Circle students had very little increase in ability/ self-efficacy over the year. This compared to SF Math Circle students who had increases in their ability/ self- efficacy over the year with the students that were in Math Circle starting and ended with the highest values. Comparing the national survey results to the SFMC results we see even higher values in the national attitudes. Overall Math Circle students have high expectations of success.

## Analysis of Results

Overall the NAMC post survey participants recorded the highest task value and expectation of success seen by the evaluator on surveys completed in the last four years. As we discussed previously, the literature supports that students who believe that mathematics is important to them personally and that mathematics has some usefulness to them in terms of their future career goals have high task value beliefs. Thus, these survey results support that Math Circle increases the value of mathematics for students involved.

## Beyond Expectancy-Value Theory

*“Math Circle has exposed me to other types of math outside of my school. It’s a good way to keep thinking during the weekend.”* - NAMC Student.

It was important to the evaluators to look beyond expectancy-value theory in designing the evaluation of Math Circle impact. Beyond the task values questions found in the literature, we added a set of questions to the surveys that measure the nature of mathematics, career plans, and safe mathematical community. These questions are used to better understand the difference between the cross-section of students who are non-Math Circle participants and Math Circle participants and the impact of this program over the course of the year.

## Nature of Mathematics

The idea that we can study the impact that outreach programs have on students’ knowledge of the nature of a discipline is linked back to science outreach studies. Students are evaluated not just on the science they understand but on how much they understand the life of a scientist. The evaluator hadn’t found clear connections of this work back into mathematics but the following questions were used to start evaluating this component of the Math Circle impact:

- Problem solving is an important part of mathematics?
- Have you met a mathematician before?
- Describe what a mathematician is. What do they do all day?

Overall responses show that Math Circle students have had more exposure to craft of mathematics and have gained a larger understanding of the field. This is exposed further in the next set of questions as more Math Circle participants select Science, Technology, Engineering and Mathematics (STEM) based careers. It is also illuminated in the students’ descriptions of what a mathematician is:

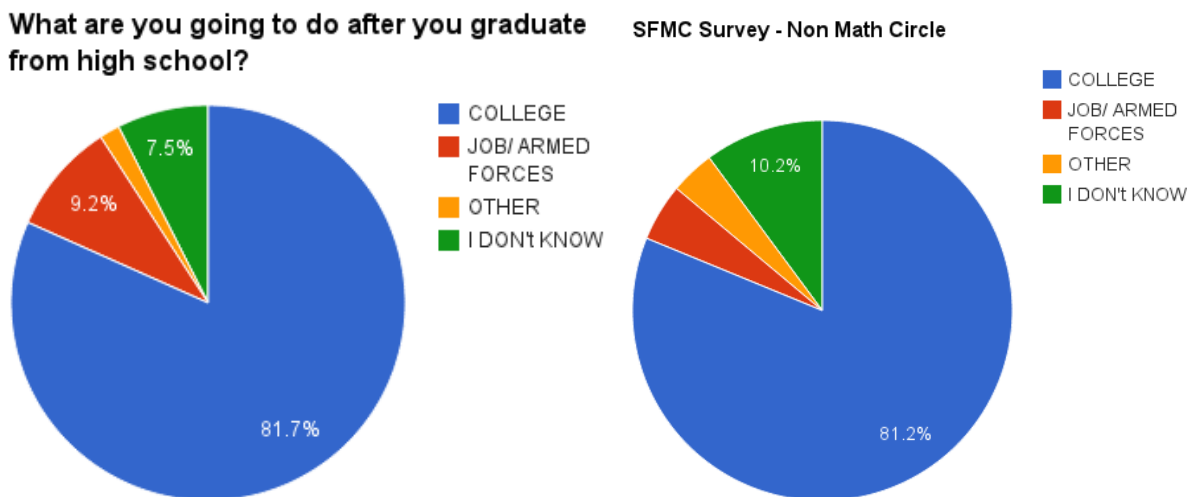
- *They work on math theories, but they don’t lead a totally different life from other adults.*
- *a mathematician is some one who enjoys confronting problems and doesn’t mind that they might be impossible to solve . the mathematician that I’ve met, does his normal work and uses every spare moment to think about the problem that he was working on this morning.*
- *A professional that uses reasoning and problem-solving that can be applied to every day life.*

- *A mathematician is someone who does math for a living. They discover stuff that is the best thing since the Pythagorean theorem.*
- *A person that studies math as a science. Including its properties in the real world.*
- *They obviously do math, but most importantly, they use their problem solving skills to break things apart and be able to formulate a conclusion.*
- *A mathematician does mathematical discoveries. They enjoy solving problems that nobody has ever attempted before. They see math not as pressure but a great source of joy.*
- *Mathematicians usually work with statistics, analysis, etc. Professional mathematicians perform a number of different roles, such as accounting, engineering analysis, teaching, research. They can also work for the government breaking codes and encryptions. They do work very closely with the engineers too. As a matter of fact, any engineer or scientist of any discipline is basically a mathematician with a specialty.*
- *A mathematician is someone who does math problems as an important part of his or her job.*

As we stated, the question to describe a mathematician originates in a study of students’ understanding of the nature of science. Younger students were asked to draw a scientist as pre-survey and often those scientist pictures are the national stereotype of a scientist, white males in lab coats. At the end of the outreach program students draw a scientist again and the gender will change, the coat will leave, and often the scientist picture will look like the students themselves or their teacher. You can see similar themes are achieved by Math Circle students’ descriptions of mathematicians. Not all the mathematicians referred to are male, they believe the mathematicians are normal people who do exciting work. This is a huge change from the national pre-conception of mathematicians and is crucial to the students’ understanding of their potential role for future participation in STEM, specifically mathematical careers.

### Future Participation on STEM

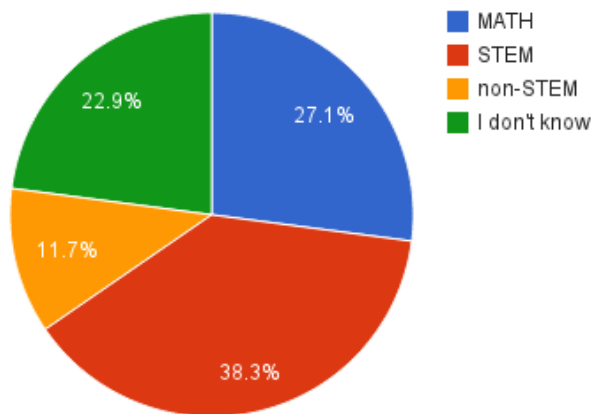
As we’ve stated previously, Math Circle programs are designed to increase the quality and quantity of students who become mathematics educators and researchers. One way to evaluate the impact of Math Circles on this aspect is to review students’ future STEM goals. The survey asked 2 questions, “*What are you going to do after you graduate from high school?*” and “*If you were in college now, what major would you choose?*”. The students’ responses were classified into groupings (college/ job/ etc. and STEM/ Non-STEM) by the evaluator based on current college distinction between the majors (for example business major or art was considered non-STEM while engineering, computer science, and biology were all consider STEM majors).



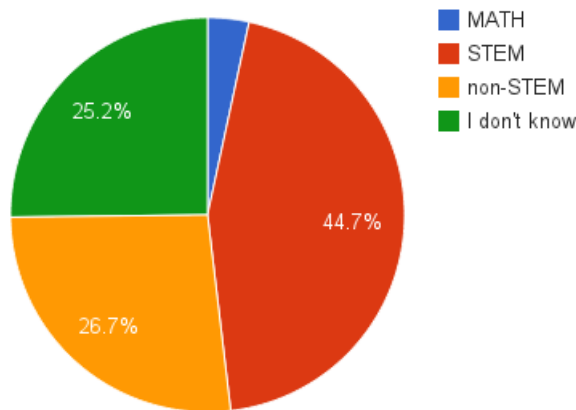
The career plans question provides the clear motivation for why this survey is not successful for elementary students. As previously discussed, several of the elementary students gave responses of the form, “*Honestly, I think I am too young to think about that yet*”. This isn’t representative of an elementary students’ response and is most likely very skewed by parental involvement in younger students responding to the surveys. Looking at the middle and high school student responses of Math Circle vs non-Math Circle participants there wasn’t that much of a distinction in their plans. This compares to four years ago when the evaluator first asked this question and only 70% of the

non-Math Circle participants planned to go to college. This is wonderful news for the nation, as more and more students plan to continue their education beyond college.

### If you were in college now, what major would you choose?



### SFMC Survey - Non Math Circle



Looking at the major, 65.4% of the NAMC participants indicated they would choose a major that involved mathematics and mathematical problem skills. This compared to only 44% of the non-Math Circle students. These are numbers that are exciting to funders that are hoping the Math Circle type programs will provide their future workforce.

### Safe Mathematical Community

*Math Circle is... Fun, great environment where everyone is supportive of each other. Like-minded students and instructors come together to learn, socialize and challenge themselves. - NAMC Student.*

Beyond the academics of our program, our objective at Math Circle is to develop a safe mathematical community for all participating students and teachers, i.e., a community where participation has little expected emotional cost. We believe that a safe mathematical community and a mathematical rich environment will result in:

1. increased individual mathematical competency;
2. increased individual problem solving competency;
3. individual students choosing to do mathematical activities;
4. individual students choosing to explore harder mathematical tasks;
5. increased persistence on mathematical tasks;
6. an increased understanding of the nature of mathematics.

The idea of safe mathematical community is not one that we have thus far found questions for within the mathematical education research. Thus we have tested the following questions to challenge our students' concept of safe mathematical community:

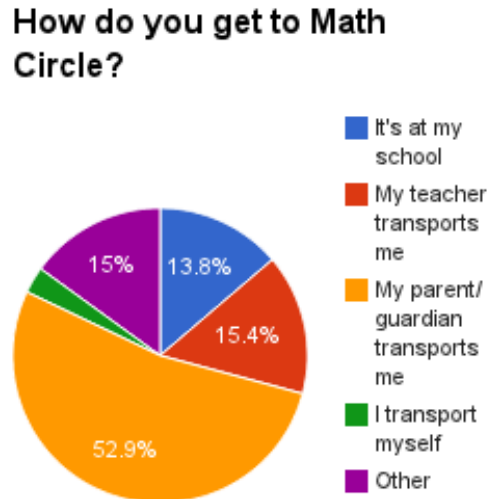
- Being a Math Circle participant is a major part of who I am.
- In our math class, its OK to make mistakes as long as you are learning.
- I have friends in my Math Class

Over the last four years the evaluator has seen that these questions do address the question of safety for the SFMC students. In using the survey questions for the national students we saw that the national programs are maintain safe community environment for the students and teachers. The students believe they have friends and are able to make mistakes within the Math Circle classes. This questions will be further reviewed for the national program but overall this supports the national effort is being conducted by great mathematical leaders that create strong mathematical classrooms.



## Travel to Math Circle

In designing a national survey we have the opportunity to better understand, not just the mathematical impact on the participating students but also to understand the national workings of Math Circles. One such question that had surprising results was the question, “How do you get to Math Circle?”



Previous to this survey it was anticipated that a majority of the national Math Circle programs had students being transported by parents. This initial survey shows that this might not be the case. When the survey is broadened to include more national participants then we will have a clearer picture but having so many students who are transported by teachers or who have programs at their school is of interest to funders who are more interested in programs that reach a broader audience beyond students from already enriched backgrounds.

## Analysis of Surveys

*“The math was fun and I never did that kind of math in my whole life until now. I enjoyed the math.”* - NAMC Student

As we explained, there is research to support the fact that measurement of expectations and values of students combine are to create a related to measurement of program impact on students[3,4,7]. The results of the evaluation over the last several years of SF Math Circle support that the evaluator have developed a tool that measures the impact of Math Circle on individual student mathematical problem solving skills and understanding of mathematics. Our use of this tool with the national program demonstrates that Math Circle is having a positive impact on the mathematical attitudes of the students involved. We look forward to continuing to develop and use this tool to show future impact of the Math Circle program.

## Future NAMC Survey Plans

We created the SFMC program evaluation to help a long-time Math Circle funder understand the impact that Math Circle had on participating students. The San Francisco program is not unique in this funder request, as Math Circles reaches its 15 year mark as a national program and continues to grow there is a growing insistence from funders to demonstrate the value-added from these programs.

The NAMC Post-survey was the first attempt at taking the survey national. Lessons were learned included:

- The online format was confusing for some participants, most especially the online waiver.
- Need to adjust some of the questions to work with a broader set of Circles
- Age levels of participants needs to be 13 and above.

We are working to make adjustments to the 2014-2015 survey to address these concerns. Unfortunately the first need is to address Human Subjects Approval from the new campus of the NAMC program evaluator, Dr. Brandy Wieggers. Until this approval is achieved the evaluation work cannot continue. The CWU training has been completed but the new waiver process for minors needs to be outlined and approved. Once approval is provided the plan is to contact the larger NAMC programs to provide the opportunity for them to participate in the NAMC survey. Information will be provided in regards to the following components:

1. Waivers
2. Process/ Timeline for year
3. Expected Reports
4. Results of 14 post-survey

This will reduce the confusion and questions that were addressed and worked out in the 2014 Post-Survey. Nationally there has been huge response to the outlined survey plans and we look forward to helping the NAMC community by continuing this work.

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