



## MathILy 2015 Final Report

### Preface

MathILy was approximately the same size its third year as in its second year. There were multitudes of minor issues but nothing catastrophic happened, and we held a program with excellent students who learned a lot of mathematics and a lot about how to think and speak and write mathematically.

### Program Preparations

#### Promotions

*Electronic:* Emails were sent to promising applicants from 2014 and to MathILy 2013 and 2014 participants. MathILy continues to be listed on several high-traffic webpages, including the AMS summer programs page, the MIT Admissions' "Prepare for MIT" summer programs page, and the Art of Problem Solving Wiki summer programs page.

*Print:* 2000 full-color quarter-sheet fliers with the MathILy logo and basic information on one side, and a multi-part mathematics problem on the reverse were distributed at national and local mathematics contests and enrichment activities. Fliers were handed out at HMMT and ARML.

*Other Activities:* At HMMT, sarah-marie gave a Mini-Event (on colorings of polyhedral skeleta) and was available to talk with students, parents, and coaches at various times. She also offered a Math Jam (on  $d$ -cubes and  $d$ -simplices) through the Art of Problem Solving that was followed by a {MathILy, MathILy-er} Q&A, and gave the Friday Night Lecture (on tilings of grids on surfaces) at ARML Penn State, before and after which she met with potential applicants, admitted students, and alumni/ae.

### Applications

*Statistics:* We received 460 Short Forms, 166 Not-as-Short Forms, and 151 EARs. There were 128 completed applications, of which 42 became admitted students. Ten students declined for other national-level summer mathematics programs. Our current admissions rate is roughly 33%.

*Demographics:* Not-as-Short Forms originated from at least 25 US states, one US territory, and 18 foreign countries (representing all populated regions of the world except for Africa, Central Asia, and South America).

The data in the following table was measured where possible and approximated otherwise.

Percentage	Female	East Asian	South Asian	Latin@	Other of color
Short Forms	36%	36%	15%	6%	2%
EARs	39%	34%	10%	3%	1%
Attending	31%	42%	5%	4%	0%

*Financial Aid:* Donations earmarked for financial aid totaled \$2000, and we were awarded an AMS Epsilon Fund grant for \$8,250 (required to be used for financial aid). We were able to award \$15,650 in financial aid to MathILy participants because of the budgetary stability provided by the Epsilon Fund grant and because of lower-than-budgeted costs. Every admitted student's demonstrated need was met.

## Personnel

*Academic:* Lead Instructors were dr. sarah-marie belcastro (U. Massachusetts-Amherst and Smith College, Ph.D. University of Michigan 1997) and Dr. Thomas C. Hull (Western New England U., Ph.D. University of Rhode Island 1997). Lead Instructor Dr. Cynthia Vinzant (North Carolina State U., Ph.D. University of California, Berkeley 2011) taught during the Week of Chaos.

Apprentice Instructors were Hannah Alpert (grad student, MIT), Brian Freidin (grad student, Brown), Nathan Harman (grad student, MIT), Lisa Piccirillo (grad student, U. Texas, Austin), Max Engelstein (grad student, U. Chicago), and Corrine Yap (undergrad student, Sarah Lawrence College).

Biographical information and prior experience are listed at <http://mathily.org/dramper.html>.

*Administrative:* The Director was dr. sarah-marie belcastro. The excellent MathILy Minion was Madison Stuart (Smith College B.A. 2006 in Mathematics and German; graduate work in information science at the University of Michigan). The role of Protector and Responder in the MathILy Environment (PRiME) was shifted between three different individuals over the course of the program.

*Advisory Amalgam:* These individuals gave advice on academic and practical aspects of MathILy.

[Dr. Douglas J. Shaw](#), mathematics faculty at University of Northern Iowa

[Dr. Ruth Haas](#), mathematics faculty at Smith College

[Mr. James Cocoros](#), mathematics faculty at Stuyvesant High School

[Dr. Dylan Shepardson](#), mathematics faculty at Mount Holyoke College

[Dr. Carol E. Fan](#), operations researcher (currently at Gwynnie Bee)

[Dr. James Tanton](#), mathematician, currently Visiting Scholar at the [MAA](#)

[Dr. Joshua Greene](#), mathematics faculty at Boston College

[Dr. Emily Peters](#), mathematics faculty at Loyola University Chicago

[Wing L. Mui](#), mathematics faculty at the Overlake School

[Dr. Thomas Hull](#), mathematics faculty at Western New England University

[Dr. Josh Laison](#), mathematics faculty at Willamette University

## Student Demographics:

*States represented by MathILy students, from east to west:* Massachusetts, New York, New Jersey, Pennsylvania, District of Columbia, North Carolina, Illinois, Iowa, Texas, Nevada, California.

*Countries outside of the United States represented by MathILy students, from east to west:* China, Poland, and Canada.

*Gender breakdown:* 8 females, 18 males.

*Ages:* There were four 14-year-olds, one of whom turned 15 during the program; six 15-year-olds; eight 16-year-olds; seven 17-year-olds; and one 18-year old, who turned 19 mid-program.

*Academic backgrounds:* 15 students had already taken calculus (4 had also taken multivariable calculus), and 3 had taken college linear algebra. Nineteen students had attended mathematics programs in previous summers.

## What Happened at MathILy 2015?

### Academics

**Classes:** Each weekday we had 4 hours of morning class, 1–1.5 hours of Daily Gather, and 3 hours of evening class, for at least 8 contact hours per day (not counting mathematical conversations outside of class). Weekends were a bit idiosyncratic, but the general Saturday template consisted of 4 hours of morning class and 1–2 hours of afternoon Life Seminar.

The basic curricular structure was two weeks of core curriculum, called Root Class (after the root of a graph theoretic tree, and after the idea that the material strengthens student grounding much as the roots of a tree do), followed by one week of short topical classes, called Week of Chaos, followed by two weeks of focused-topic classes, called Branch Class (after branches of mathematics, and after the idea that tree branches grow from a strong trunk nourished by roots).

*Root Class:* There were two Root classes, each with 13 students, one taught by sarah-marie and Nate, and the other taught by Tom and Hannah. The material included from our core curriculum was linear and affine algebra and geometry (including equations and intersections of hyperplanes, span, linear independence, and dimension), combinatorics, graph theory, definition and examples of groups, isomorphism and homomorphism for various categories, probability spaces and expected value, and basic cardinality. Of course, all of this material was treated with full proofs given by the students.

*Week of Chaos:* Students indicated which of 37 potential topics they would be excited to learn about, from which instructors decided on a list of classes offered. These were Valuing Primes ( $p$ -adics), Randomly Walking About, Generatingfunctionology, Non-boring Consequences of Long Division, Knot Theory–Practice, Not-so-Complex Analysis, Strange Geometries, Moar Combinatorics, Projective Geometry, Math Saves the World: Combinatorial Optimization, Tropical Geometry, Game Theory, Fractals, A Class on Simplicity (computational complexity classes), and Ordinality. Each student was placed in 5 classes according to expressed preferences. About half of these classes benefitted substantively from the students' prior work with linear algebra; another fourth used specific material from the core curriculum. Students and instructors alike were very pleased with the amount of material and level of detail achieved in such short courses.

*Branch Classes:* We offered two Branch classes (with the same topics as in 2013), one by sarah-marie, Hannah, and Brian on topological graph theory (TGT), and the other by Tom, Max, and Corrine on the mathematics of paperfolding. The instructors were pleased by the progress made by their students.

*Pedagogy:* All classes were conducted using inquiry-based learning, with most class time spent with students working in groups or presenting their insights to each other, and a much smaller amount of time used by faculty conducting discussion from the board.

*Feedback:* Students received feedback in multiple ways. They received instant verbal feedback on the correctness of their mathematical ideas during class, as well as feedback on use of notation, language, and presentation style. They received written feedback on the problem solutions and proofs they handed in each day, always within 24 hours. Near the end of Root and Branch classes, each student was asked to write an introspective self-evaluation. The self-evaluations were discussed by the student's instructors, and the instructors then held a 5–20 minute meeting with each student to give overall feedback on the student's progress at MathILy and advice for the future.

**Daily Gatherers:** Each instructor gave a Daily Gather. The Daily Gather timeslot was also used to show Math Movies once per week. These included expository films made by the Mathematical Association for America's Geometry Project, films from the National Film Board of Canada, and narrated animations made by individual mathematicians or research groups. The remainder of the Daily Gatherers were interactive presentations given by visiting mathematicians. Some visitors were local (from Bryn Mawr, Swarthmore, and Lafayette Colleges, and Lehigh University) and visitors also came from Georgia, Iowa, Maryland, Massachusetts, Oregon, western Pennsylvania, and Texas.

## Extracurriculars

*Life Seminars:* There were three weekend Life Seminars offered. The first was on practical matters (such as how to address faculty in person or by email and how to do laundry). The second was on careers in the mathematical sciences, careers that heavily use the mathematical sciences, and career opportunities for those with mathematical science training (oops—that's everything). The third Life Seminar was on how to choose colleges to which to apply, and included an exchange of information about past student, instructor, and visitor experiences at several colleges.

*Other all-program activities:* At the end of the first week, we walked over to Haverford College, had a mini Daily Gather in their math lounge, and returned to Bryn Mawr. We then gathered in our larger classroom to play a rousing game of telephone pictionary, and smaller games of Orthogonal Questions (suggested by MathILy-Er Director Jonah Ostroff). The program went by train to Philadelphia for the entire Saturday right after Week of Chaos. The next day, the program was treated to ice-cream cones and dishes at a local shop on National Ice Cream Day.

*Non-program-wide activities:* A few students regularly used the indoor athletic facilities. One staff member and two students went swimming most mornings. A couple of times each week students played frisbee after dinner. A student led three well-attended ballroom dance lessons.

A group of students regularly played pool and ping-pong in the Campus Center in the afternoons. Mid-program, a large Zometool set was released into the common room and was played with sporadically for the rest of the program. Board and card games were played from time to time. A few students regularly practiced instruments, and some taught others to play piano. One weekend there was an impromptu jam session in a front living room.

Most nights there were optional Bedtime Stories; attendance was a bit more than half of the students and a third of the staff, and some students regularly stretched or did calisthenics while listening. Bedtime Stories were often followed by a student dramatic reading of a [random.org](http://random.org)-generated page of *Dianetics* (found in the common room), generally to much laughter.

On the last night of the program, we brought lots of puzzles and games to the common area and many of the students played with them for some hours.

## Administrative matters

*Facilities at Bryn Mawr:* Again, everyone liked the facilities and the campus as a whole. We were in the same part of the same dormitory as last year. Most students had air-conditioned single rooms, but a few had two-room doubles or three-room triples. We were given the same tables-and-chairs classrooms in the math-and-physics floor of the science building as before. Janitorial service was extensive; every night chalkboards were cleaned and the rooms were tidied, and every day bathrooms were cleaned.

*Campus Location:* Bryn Mawr is a safe and tree-filled suburb of Philadelphia, located on a major train line into the city. Bryn Mawr College is a few blocks away from the Bryn Mawr train station, and also a

few blocks away from a major street that parallels the train line and has lots of shops, libraries, post offices, etc. This location was convenient for our purposes because almost no driving was needed during the program; most of our desired destinations were a short walk away. Students were able to depart campus on foot in groups to go out for dinner or shopping. It was also straightforward to take the program into the city, and use of the train made our travel flexible.

## Post-Processing

*Post-program staff meeting:* After the students had left, the staff convened to evaluate various aspects of the program and to discuss how we could improve the workings of MathILy in future.

We are generally happy with the Root core curriculum. Our treatment of alumni in Root worked well. They were assigned to collectively recall and write out carefully certain parts of the material and then provided with short problem sets that generalized these topics. We plan to create a more thorough collection of guided inquiry problem sets intended for qualified students to review and extend various Root topics. We also discussed various regularizations of our academic work, including intended tweaks to the pedagogical mix we use in morning classes versus evening classes. We have started a list of particularly useful problems for Root class, and created a set of tips for various Week of Chaos topics.

Collectively, we felt that the students were stronger this year than in the two previous years, and we were very pleased with how much some of the students grew mathematically.

*Impact:* We were pleased by the following:

- One of our strongest students told us that she had never thought of being a mathematician before, as she didn't know about the range of possible careers, but was now considering pursuing mathematics.
- Another student mentioned that MathILy was the first time she'd ever had to think about ideas for a few minutes before understanding them, and that she had developed a curiosity about mathematics she hadn't had before.

*Finances summary:*

The income from student fees (some discounted) was \$104,565.

An AMS Epsilon Grant award and donations for financial aid totaled \$10,250.

Total MathILy income: \$114,815.

Administrative expenses (insurance, fliers, etc.) totaled approximately \$2646.

Total wages (instructors, PRiME, Minion, Director) were approximately \$31,900.

Travel costs (Daily Gather speakers, instructors) were approximately \$3936.

Program expenses (supplies, program outings) were approximately \$1940.

Site (Bryn Mawr College) charges, including housing, meals, and duplications were \$63,688.

Total MathILy expenses: approximately \$104,110.

We were fortunate to achieve savings of more than \$13,000 in wages because multiple instructors were federally supported and thus worked as volunteers. This enabled use to allocate about \$5,400 more in need-based financial aid than was budgeted.

We were also fortunate to receive in-kind donations of volunteer time and travel expenses related to {MathILy, MathILy-Er} (though mostly MathILy), worth roughly \$16,650, and software from Wolfram Research, valued at \$3300.