



MathILy 2018 Final Report

Preface

MathILy grew to nearly full size this year—we had 44 students participate in the program. As usual, 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; staff agreed that overall, this was our best summer yet.

Program Preparations

Promotions

Electronic: Emails were sent to promising applicants from 2017 and to MathILy 2017 participants. MathILy continues to be listed on several high-traffic webpages, including the summer program listing pages hosted by the AMS and MIT Admissions (the top referrer by far). Web traffic varied from 2000–3200 hits/week, with more than half of the traffic from abroad.

Print: About 3760 fliers with basic information on one side and a multi-part mathematics problem on the reverse were distributed to 25 national and local mathematics contests. Fliers were handed out by humans at HMMT (November and February) and ARML Penn State.

Other Activities: We held a {MathILy, MathILy-Er} Yearly Gather at the Joint Mathematics Meetings (word puzzles on the Fano plane, 36 participants). At HMMT February, sarah-marie gave a Mini-Event (on adding in geometry, 30 attendees) and at ARML Penn State she gave the Friday Night Lecture (on aperiodic sequences and tilings, 204 attendees). At both events sarah-marie met with potential/current applicants, alumns, coaches, and a few parents. She also offered an Art of Problem Solving Math Jam (65–85 attendees at any given time) combining an old EAR problem with some {MathILy, MathILy-Er} Q&A.

Applications and Admissions

Statistics: We received 805 Short Forms, 296 Not-as-Short Forms, 280 EARs, and 247 completed applications. We admitted 54 students, for an admissions rate of about 21%—lower than any prior year. Seven students declined for other summer mathematics programs.

Demographics: Applicants originated from at least 36 US states and 25 foreign countries (representing mostly North America, Europe and Asia, but also including South America and Africa).

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

Percentage	Female	East Asian	South Asian	Latinx	Middle Eastern	Other of color
Short Forms	40%	39%	19%	4%	4%	2%
EARs	34%	44%	13%	1%	2%	1%
Attending	30%	55%	7%	0%	0%	0%

Financial Aid: We awarded \$9750 in financial aid to MathILy participants, of which \$6000 was provided by the AMS Epsilon Fund. We met the level of demonstrated need for all admitted students who applied for financial aid. As in 2017, few students applied for financial aid.

Personnel

Academic: Lead Instructors were Dr. Hannah Alpert (Ohio State U., Ph.D. MIT 2016), dr. sarah-marie belcastro (Smith College Research Associate, Ph.D. U. of Michigan 1997), Dr. Brian Freidin (IAS, Ph.D. Brown U. 2018), Dr. Nate Harman (U. of Chicago, Ph.D. MIT 2017), Dr. Thomas C. Hull (Western New England U., Ph.D. Univ. of Rhode Island 1997), Dr. Adam Marcus (Princeton U., Ph.D. Georgia Tech 2008), and Dr. Emily Peters (Loyola Univ. Chicago, Ph.D. UC Berkeley 2009).

Apprentice Instructors were Connor Ahlback (graduate student, U. Washington), Gideon Leeper (undergraduate at Caltech and MathILy 2013 alumni), Joshua Mundinger (entering graduate student at U. of Chicago and MathILy 2013 alumni), Anila Yadivalli (graduate student, NCSU), and Corrine Yap (graduate student, Rutgers U.).

Biographical information and prior experience are listed at [Dramatis Personae](#).

Administrative: The Director was dr. sarah-marie belcastro. The excellent {MathILy, MathILy-Er} Minion was Madison Stuart (Smith College B.A. 2006 in math and German; graduate work in information science at the University of Michigan). The über-competent Protectors and Responders in the MathILy Environment (PRiMEs) were Namrata Basu (Bryn Mawr math major) and Kimball Strong (UC Berkeley math major).

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 University of Hawaii

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

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

[Dr. Carol E. Fan](#), operations researcher (currently Director of Operations Research at [SoFi](#))

[Dan Zaharopol](#), Executive Director of [BEAM](#)

[Dr. James Tanton](#), mathematician, currently Ambassador for 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, roughly from east to west: Massachusetts, New York, New Jersey, Pennsylvania, Maryland, Virginia, North Carolina, Michigan, Illinois, Missouri, Minnesota, California, and Washington.

Countries outside of the U.S. represented by MathILy students, roughly from east to west: India, Canada.

Gender breakdown: 13 females, 31 males.

Ages: Eight 14-year olds; ten 15-year olds; seventeen 16-year olds; and nine 17-year olds.

Academic backgrounds: A bit over half of the students had taken calculus II or equivalent (and 14% had also taken multivariable calculus), 4 had taken linear algebra, and 2 had taken number theory. Four students had not yet taken precalculus. Twenty-five students had attended summer mathematics programs before.

What Happened at MathILy 2018?

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 varied, but most Saturdays had 4 hours of morning class and 2 hours of 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 three Root classes, each with 14 or 15 students, one taught by {sarah-marie, Josh}, one taught by {Hannah, Connor, Gideon}, and one taught by {Nate, Anila}. Our core curriculum consisted of linear and affine algebra and geometry (including equations and intersections of hyperplanes, span, linear independence, transformations, and dimension), combinatorics, graph theory, definition and examples of groups, isomorphism 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. One returning student luxuriated in the entirety of the advanced linear algebra curriculum, and a first-time student worked through several advanced linear algebra worksheets during Root.

Week of Chaos: Students indicated which of 56 potential topics they would be excited to learn about, from which instructors decided on a list of 27 classes offered. These were: Algebra, a singular passion (subgroups and morphisms), In the long run (random walks), Integrate like the French (Lebesgue integration), Don't have Bad Taste (graph coloring), Origametry, Rook Research (non-attacking rook arrangements on modified chessboards), p -adicts anonymous (p -adics), The Ocean is Big and Blue (Ramsey theory), Voting Methods, or why we can't have nice things: a proof, Projective Geometry in Perspective, Math Saves the World: Combinatorial Optimization, Non-Euclidean geometry, The characters of sprouts (representation theory), Computers: What can they do? Can they do things? Let's find out! (complexity theory), Magic Functions (generating functions), Fancy Note-Taking Diagrams (sorting algorithms), Erdős Magic (the probabilistic method), Big Finite Diff (finite difference calculus), Knot Theory, practice, Mind reading (reading the original paper on Shor's algorithm), Matrix Psychology: Theory and Application (random matrix theory), Dingöoptimization (matroids), Surreal Numbers: A Play in Five Acts, Loops on Loops on Loops (homotopy theory), Algebraic geometry (without the algebra (and the geometry)) (moduli spaces on triangles/quadrilaterals), iCalculus > Calculus (complex analysis), and Cantor Set. Each student was placed in 5 classes according to expressed preferences. Approximately 60% of these classes used specific material from the Root curriculum, and approximately 1/3 benefitted substantially from students' background in linear algebra.

Branch Classes: We offered three Branch classes, one on convex geometry (sarah-marie and Gideon), one on computational geometry (Tom, Connor, and Corrine), and a completely new one on chip-firing games (Brian and Josh). All three Branch classes used linear algebra, and two of them introduced real-world applications.

Pedagogy: All classes were conducted using inquiry-based learning, with the bulk of the 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. Likewise, students received daily written feedback on their mathematical writing. 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 Gathers: 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, films from the National Film Board of Canada, and narrated animations made by individual mathematicians or research groups. The remainder of the Daily Gathers were given by visiting mathematicians, both local (Swarthmore, Lafayette, and Villanova) and from Florida, Massachusetts, New York, and Oregon.

Extracurriculars

Life Seminars: The first Life Seminar was on practical matters such as how to address faculty in person or by email, how to properly write with chalk, and impostor syndrome. The second Life Seminar was on careers for people with mathematical science training. The third Life Seminar was on how to choose colleges to which to apply, and included an exchange of information about instructor experiences at several colleges and universities.

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 and gathered to play a rousing game of telephone pictionary. The day after Root ended, the program was treated to ice cream at a local shop on National Ice Cream Day. The program went by train to Philadelphia for the entire Saturday right after Week of Chaos.

Non-program-wide activities: At the start of the program, the World Cup was in progress so many students and staff watched bits of it obsessively during free times. The two most popular athletic activities were Frisbee (mostly tossing around a disk) and swimming, but various activities involving balls (sometimes multiple balls) also happened. One student organized events by posting notes on the dorm door card-readers declaring a time and activity for the day. Some students ran regularly, and because of the heat, one ran from 10:15–11:30pm every weeknight. A few students practiced yoga, though rarely together. Card games of various sorts were popular, as were social engineering games. Fish (a variant on "Go Fish") was popular and there was a Fish tournament that went so long students became bored with it by the end. Two disjoint collections of students played Pandemic multiple times each week. Most nights there were optional Bedtime Stories. Students regularly used the piano in our dormitory. We also had access to a music practice room that was frequently and regularly used. Three students and a PRiME formed a barbershop quartet that performed a very charming MathILy-specific song at the closing meeting. During the last week we discovered that one student was trying to learn ballroom dance from the internet and another was an expert, so we had a 2-hour session in the Dance Studio on the last night; we also brought lots of puzzles to the common area and many of the students played with them late into the night and again on departure day.

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 the last four years, and allocated two floors. Some students had single rooms, and others shared one- or two-room doubles or three-room triples (each with a window air conditioner). We were assigned our usual classrooms in Park Science Center. Janitorial service was extensive; every night chalkboards were cleaned and the rooms were tidied.

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—many desired destinations were a short walk away or required a straightforward and quick drive. 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 left, the staff convened to evaluate various aspects of the program and to discuss how we could improve the workings of MathILy in future.

The PRiMEs created a new document, the SemiPRiME Guide, on working together in the position. We plan to produce a better example Root class video for the pre-program teaching training session. The revisions to our Daily Gather logistics were a resounding success. Student hosting did in fact enable interactions between visitors and students. Students openly appreciated speakers sharing personal perspectives—a couple of staff members were thanked for their commentary, and at least one visitor was approached by multiple students after evening class for further discussion. We will continue both of these practices.

Instructors were pleased by student growth and achievement of this very active and strong cohort. Weaker students made progress in various ways, and several strong students seemed to go from “good” to “AWESOME.”

Impact: As usual, several students commented

- that they learned about areas of math of which they hadn't even dreamed before MathILy
- that they are now certain they want to pursue more mathematics.

Several students pointed out that they had come to appreciate subtle aspects of mathematics that they had not previously valued, such as the importance of rigorous argument and clear writing, especially in terms of being able to recognize the quality level of one's work. At the closing meeting, a student thanked us for doing individual check-ins during class to make sure everyone understood, and other students chimed in agreement.

Finances summary:

The income from student fees (some discounted) was \$190,839.

Our Epsilon Grant award was \$6,000.

Total MathILy income: \$196,839.

Administrative expenses (insurance, fliers, etc.) totaled approximately \$2,973.

Total wages (instructors, PRiMEs, Minion, Director) were approximately \$56,244.

Travel costs (Daily Gather speakers, instructors) were approximately \$3,097.

Program expenses (supplies, program outings) were approximately \$4,613.

Site (Bryn Mawr College) charges, including housing, meals, and duplications were \$118,365.

Total MathILy expenses: approximately \$185,292.

An externally administered travel grant paid for an additional \$1,162 in travel expenses. We were also fortunate to receive in-kind donations of volunteer time and travel expenses, worth roughly \$9,500 and \$414 respectively, and software from Wolfram Research, valued at \$11,244.

The net revenue of approximately \$11,500 arises primarily because four instructors were federally supported, with the remainder saved by cost underruns resulting from emergency departures. Mathematical Staircase, Inc. generates no non-program income, so programmatic surplus pays for administrative expenses such as regulatory required financial review and state corporate filings. Additionally, MathILy-Er had a substantial financial-aid-induced cost overrun this year that can be offset using MathILy net revenue. We anticipate that we will keep MathILy 2019 fees at the same level as they have been for all prior years.