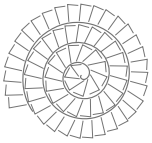

MATHEMATICAL STAIRCASE, INC.

MathILy

MathILy 2025 Final Report

Preface

As always, MathILy was composed of excellent students who learned a lot of mathematics and a lot about how to think and speak and write mathematically.

Program Preparations

Promotions

Electronic: Individual emails were sent to prior participants and promising applicants. MathILy continues to be listed on several high-traffic webpages, such as MIT Admissions' "Preparing for MIT" summer programs page. Web traffic varied from 7,700–32,700 hits/month, with about 45% of the traffic from abroad.

Print: The Minion sent about 500 fliers to contests and events.

Other Activities: We held a {MathILy, MathILy-Er, MathILy-EST} Yearly Gather at the Joint Mathematics Meetings, where at least 90 participants team-solved four Jonah-designed nonabelian SET puzzles, the last of which used the solutions to the other three. In early April sarah-marie offered an Art of Problem Solving Math Jam (~55 participants) on Multibackwards Numbers that included a {MathILy, MathILy-Er} Q&A.

Applications and Admissions

Statistics: We received 2506 Short Forms, 919 Not-as-Short Forms, 811 EARs, and 690 completed applications We admitted 62 students, for an admissions rate of ~9%. Sixteen students declined, eleven for other summer programs and one because of the unfriendliness of the current US political situation to international students. Thus, our current yield rate is roughly 74%.

Demographics: Applicants originated from at least 42 US states and 44 foreign countries (representing North/South America, Western/Eastern Europe, East/Central/Southeast Asia, West/South Africa, and the Middle East). The data in the following table was measured where possible and approximated otherwise; the final row reflects a post-program demographic survey.

Percentage 2025	Female	NB	East Asian	South Asian	Latinx and indigenous	Middle Eastern	Black
Short Forms	33%	0.5%	41%	19%	4%	10%	1%
EARs	29%	1%	57%	15%	3%	3%	1%
Attending	30%	7%	65%	15%	7%	2%	0%

Financial Aid: We awarded $21,500 in financial aid to MathILy participants ($8,500 to international students and $13,000 to domestic students), and used grants from Jane Street ($16,500) and the AMS

Epsilon Fund ($5,000) for this purpose. 11% of admitted students applied for financial aid; we met the demonstrated need of all applicants.

Personnel

Academic: Lead Instructors were dr. sarah-marie belcastro (Math Staircase Inc., PhD U. of Michigan 1997), Dr. Brian Freidin (University of San Diego, PhD Brown U. 2018), Dr. Alice Mark (Vanderbilt U., PhD UT-Austin 2015), Dr. Hannah Alpert (CCR La Jolla, PhD MIT 2016), Dr. Thomas Hull (Franklin&Marshall, PhD U. of Rhode Island 1997), and Dr. Berit Givens (Cal Poly Pomona, PhD UW-Madison 2003). Apprentice Instructors were David Gonzalez (UC-Berkeley PhD 2025, MathILy 2014), Jessie Tan (grad student at UC-Berkeley, MathILy 2014), Frank Lu (grad student at Harvard U., MathILy 2018), Nadav Kohen (Indiana U. PhD 2025, MathILy 2015), and Natasha Ter-Saakov (grad student at Rutgers U., MathILy 2014–15). 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 U. of Michigan). The PRiME FACToRs (Protectors and Responders in the MathILy Environment and Facilitators of Activities and CriTiquers of wRiting) were Vera Choi (undergrad Tufts U., MathILy-EST 2023), Jan Fedyszyn (undergrad Brown U., MathILy 2022–23), Jack Correy (undergrad Stanford U., MathILy 2021–22), and Lily Stolberg (entering graduate student U. Michigan). The PRiME FACToRs had academic roles as well.

Advisory Amalgam: These people were available for advice on academic and practical aspects of MathILy.
Dr. Douglas J. Shaw, mathematics faculty at University of Northern Iowa
Dr. Ruth Haas, (retired) mathematics faculty at University of Hawaii
James Cocoros, mathematics faculty at Hunter High School
Dr. Dylan Shepardson, mathematics faculty at Mount Holyoke College
Dr. Carol E. Fan, operations researcher (currently Operations Data Science Lead at Apple)
Dan Zaharopol, Executive Director of BEAM
Dr. James Tanton, mathematician
Dr. Joshua Greene, mathematics faculty at Boston College
Dr. Emily Peters, mathematics faculty at Loyola University Chicago
Wing L. Mui, Seattle-area comic store owner, artist, and former mathematics teacher
Dr. Thomas Hull, mathematics faculty at Franklin&Marshall College
Dr. Josh Laison, mathematics faculty at Willamette University

Student Demographics

U.S. States represented by MathILy students, roughly from east to west: Massachusetts, New York, New Jersey, Pennsylvania, Delaware, Maryland, Virginia, Florida, Georgia, Illinois, Iowa, Minnesota, Kansas, Washington, and California.
Countries outside of the U.S., roughly from east to west: South Korea, China, the Philippines, Singapore, Romania, and the UK.
Gender breakdown: There were 14 female, 4 nonbinary, and 28 male participants.
Ages: There were nine 15-year-olds, twenty-one 16-year-olds, fifteen 17-year-olds, and one 18-year-old.
Academic backgrounds: Three-fourths of the students had taken calculus II (and 24% had also taken multivariable calculus) and five had taken linear algebra. Three students had not yet taken precalculus. Nineteen students had attended summer mathematics programs before.

What Happened at MathILy 2025?

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, as always, a bit idiosyncratic, but the general Saturday template consisted of 4 hours of morning class and 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 three Root classes, each with 15 or 16 students, one taught by {sarah-marie, David, Vera}, one taught by {Hannah, Jack, Jan}, and one taught by {Brian, Frank, Lily}. 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, examples of groups, isomorphism for various categories, probability spaces and expected value, and basic cardinality. Of course, students gave full proofs for all of this material.

Week of Chaos: Students indicated which of 54 potential topics they would be excited to learn about, from which instructors decided on a list of 27 classes offered. These were: Little Lights (finite fields), Password? (zero-knowledge proofs), Not-Quite-Real Numbers (surreal numbers), Groupers at Breakfast (geometric group theory), Mixing Potions With the Magic of Prime Divisors: Number theoretic functions and Möbius inversion, Origametry, Puffin Privacy (cryptography), Game Theory, Be There or Be Square (quadratic reciprocity), Two Truths and a Lie (error-correcting codes), Fishbox Party (representation theory), Imagine That! (complex analysis), Polynomial Counting (combinatorial nullstellensatz), Math Saves the World: An Introduction to Infectious Disease Modeling, Inter-species Alliance Geometry (projective geometry), Wiggles and Squiggles (homotopy theory), Travel Tips: How to Get Familiar with Atlantis (random walks), Class of Chaos!, Hats and Pebbles (finite-state automata), Knitting Mathematics and the Mathematics of Knitting, Breaking News: MathILy Solves Democracy! (voting theory), How to Fit a Message in a Bottle (information theory), String theory? Knot!!, The Laser Problem (the Kakeya problem), Dreaming of Numeric Shee-p (p-adics), Don't Solve for x: Generating Functions, and DJ Lebègue and BTS. Student preferences guided placement of each student into 5 classes. About half of these classes used specific material from the Root curriculum, nearly 1/4 benefitted substantially from students' knowledge/understanding of linear algebra, and nearly 1/3 used technology in a significant way.

Branch Classes: The Branch classes were on topological graph theory (sarah-marie and Jan and Jack), one on chip-firing games on graphs (Brian and Jessie and Vera), and one on discrete and convex geometry (Tom and Frank and Lily). All three Branch classes used linear algebra, all three used computer algebra systems, and all three 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. Students were assigned to take comprehensive notes for future class reference, and after instructor review (and revision) were copied and distributed to the class.

Feedback: Students received feedback in multiple ways. During class, they received instant verbal feedback on the correctness of their mathematical ideas, and also 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.

Interactions with MathILy-EST: This year MathILy-EST participants mainly kept to themselves socially and collaborated with MathILy students at Daily Gathers throughout the program. Additionally, each MathILy-EST participant took a Week of Chaos class.

Daily Gathers: Each instructor gave a Daily Gather, as did the MathILy-EST researchers. We had four external visitors. Each Daily Gather speaker (both visitors and staff) provided some insight into that person's perspective on the mathematical enterprise and/or way of being a mathematician. The Daily Gather timeslot was also used to show Math Movies once per week including expository films and animations.

Extracurriculars

Life Seminars: There were five weekend Life Seminars offered, many with time for open questions. The first was on practical matters such as how to address faculty in person or by email, and impostor syndrome. The second Life Seminar was on careers for people with mathematical science training and included both Zoom and in-person visitors. The third Life Seminar was about preparing for Branch, when to start research, and issues surrounding collection of demographic information. The penultimate Life Seminar was on how to choose colleges to which to apply, and included advice from MathILy-EST participants. The final Life Seminar, held the following afternoon, was on how to readjust to the non-MathILy world post-MathILy.

All-program activities: At the end of the first week we we walked over to tour Haverford College; after Week of Chaos we trained to Philadelphia for the afternoon and the next day celebrated National Ice Cream Day by treating the program to ice cream at a local shop.

Social activities: Soccer and ping-pong were popular, the latter sometimes played in the dorm with cell phones as paddles. Several students walked the labyrinth late at night. Dominion, chess, poker, The Crew, and Innovation were often in play. At meals clusters of students played New York Times word puzzles. Most nights Bedtime Stories read from *To Shape a Dragon's Breath*. On the final night, a student unveiled (via individualized Slack messages to each student and staff member) a collaborative puzzle hunt.

In Root a student ran out of room on a board, so drew an envelope in the corner, and then re-drew the envelope atop another board and explained that she was mailing the proof to herself. Others took up this habit. What began in Root as letter-dropping disease, causing "Claim" and "Proof" to become "Clam" and "Poof," evolved into a wide variety of names for claims, proofs, and parts of an inductive proof.

The convenience store 7-11 offered free Slurpees on 7/11 and most of the program walked there to partake. One Sunday evening sarah-marie posted on Slack that she was going for ice cream and willing to lead an expedition; about 30 students came. When one female student had a birthday, a bunch of other female students organized to dress in blue (her favorite color) for a group photo, and sang "Happy Birthday" to her in the hall before Daily Gather. A student exchanged glasses with anyone who had an even vaguely similar prescription and photographed the results. A pair of students created a piece of art over time by adding a stick to a particular table each day. Six students tried to walk to Daily Gather with their shoelaces tied together. Just after dinner one day four students climbed a nearby tree and the Daily Gather visitor (an alumn) joined them. One night a student held a telescope party just outside the dorm.

In the 4+ months after MathILy ended, at least a third of the program was at least semi-regularly active on Slack, with notable events including a handful of students changing their screen names to 'Frank' and then later to variants (Sphank, Hank, etc.) and competing to get as many full nights of sleep as possible.

Administrative matters

COVID-19 precautions: Because there have been COVID-19 surges nationally every summer, we did daily testing of all staff and participants for the first 5 days. We continued to mask around concentrations of other people and to eat outdoors, and we prohibited students from leaving campus unless accompanied by a staff member. This year students were easily compliant with masking, possibly because of the warning of last year's outbreak and a student being kicked out.

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 (which hosts a farmers market on weekends), and also nearby shops that supply toiletries and foodstuffs.

Facilities at Bryn Mawr: Again, everyone liked the facilities and the campus as a whole. We were assigned our favorite dormitory with air-conditioned rooms. Two of our three classrooms in Park Science Center had floor-to-ceiling blackboards. Janitorial service is extensive at Bryn Mawr; every (early) morning chalkboards were cleaned and the rooms were tidied. The dining hall staff made a variety of extra dishes just for MathILy.

Post-Processing

Post-program meetings: As usual, the staff convened after the students left (first in person, then over Zoom) to evaluate various aspects of the program and to discuss how we could improve the workings of MathILy.

Impact: Many students commented that they felt that MathILy shifted their perspective on mathematics. They also noted that their thinking skills, learning skills, and communication skills had improved. Students said that the experience of exploring mathematics collaboratively was thrilling, that the structure and atmosphere were very engaging, and that even familiar topics were challenging.

Finances summary:

The income from student fees (some discounted) was $225,067.
Donations from Jane Street for financial aid and visitor travel were $16500+$1188.
Our Epsilon Grant award was $5,000.
Tom Hull's NSF standard grant contributed $12,740.
Max Engelstein's NSF CAREER grant contributed $14,840.

Total MathILy income: $275,336.

Administrative expenses (insurance, fliers, etc.) totaled approximately $4736.
Total wages (instructors, PRiME, Minion, Director) were approximately $103,016.
Wage-related administrative costs (payroll taxes, etc.) were $5319.
Travel costs (visitors, instructors) were $5,228.
Program expenses (supplies, MAA membership) were approximately $6,327.
Site expenses from Bryn Mawr were $158,722.

Total MathILy expenses: approximately $283,347.

We were fortunate to receive donations of software from Wolfram Research worth $18,480, and volunteer time, travel, and housing worth roughly $1200. The net loss of approximately $8,012 was expected from raising wages but not fees.