



MathILy 2014 Final Report

Preface

MathILy grew by 150% in its second year. There were again some hiccups (mainly with administrative staffing) and we again held a program with good 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 MathILy 2013 participants and to promising applicants from 2013; a newsletter was sent to a list of potentially interested parties. MathILy's website is linked from 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.

Applications

Statistics: We received 317 Short Forms, 125 Not-as-Short Forms, and 97 EARs. There were 85 completed applications, of which 38 became admitted students. Four students who declined attended other national-level mathematics programs, and one did a medical science internship; three students declined for unknown reasons, two for family trips, and two for health reasons.

Demographics: Not-as-Short Forms originated from at least 22 US states, one US territory, and 17 foreign countries (representing all populated regions of the world except for Africa, Central Asia, and Australia/NZ).

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	41%	21%	20%	6%	5%
EARs	37%	24%	7%	7%	3%
Attending	42%	35%	4%	8%	0%

Financial Aid: Donations earmarked for financial aid totaled \$389, and we were awarded an AMS Epsilon Fund grant for \$10,000 (earmarked entirely for financial aid). We were able to award \$18,100 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 (Sarah Lawrence College and Smith College, Ph.D. University of Michigan 1997) and Dr. Thomas C. Hull (Western New England University, Ph.D. University of Rhode Island 1997). Instructor Dr. Daniel Studenmund (University of Chicago, Ph.D. 2014) taught during the Week of Chaos.

Apprentice Instructors were Hannah Alpert (graduate student, MIT), Miles Edwards (graduate student, University of Chicago), and Nathan Harman (graduate student, MIT).

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 amazing Protector and Responder in the MathILy Environment (PRiME) was Corrine Yap (advanced mathematics and theatre concentrator at Sarah Lawrence College).

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, Florida, Minnesota, Texas, California, and Alaska.

Countries outside of the United States represented by MathILy students, from east to west: Japan, South Korea, China, Sweden, and Canada.

Gender breakdown: 11 females, 15 males.

Ages: There were two 14-year-olds, one of whom turned 15 during the program; four 15-year-olds; seven 16-year-olds; and twelve 17-year-olds, one of whom turned 18 during the program.

Academic backgrounds: 19 students had already taken calculus (5 had also taken multivariable calculus), and three had taken precalculus (with five students at the algebra-2 level); 2 had taken college linear algebra. Thirteen students had attended mathematics programs in previous summers.

What Happened at MathILy 2014?

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, Hannah, and Miles, and the other taught by Tom and Nate. The material included from our core curriculum was linear and affine algebra and geometry (including equations and intersections of hyperplanes, span, linear independence, and modules), 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 35 potential topics they would be excited to learn about, from which instructors decided on a list of classes offered. These were Fibonacci Number Identities and Recursive Sequences, Surfaces and Homotopy, Origametry, Crypt-s (cryptography), Complex Analysis, Alternate Geometries (projective, hyperbolic, and finite), Purely Theoretical Computers (finite-state automata), Shrinking Things (algebraic homomorphisms and quotients), Ramsey Theory and the Probabilistic Method, Network Flows, Knots and Links, Markov Chains and Hidden Markov Models, Math Saves the World: Combinatorial Optimization, Big Finite Diff (finite difference calculus), and Lebesgue integration. Each student was placed in 5 classes according to expressed preferences. A few of these classes benefitted substantively from the students' prior work with linear algebra; about half used specific material from the core curriculum.

Branch Classes: We offered two Branch classes, one by Sarah-Marie and Nate on convex geometry and polytopes, and one by Tom and Hannah on dynamical systems. The polytopes students were masterful creators of precise definitions and the dynamical systems class did a great job developing metric space theory.

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. Week of Chaos classes varied the most pedagogically.

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 of handing in work. 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 expository 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, films made by Charles and Ray Eames, and narrated animations made by individual mathematicians or research

groups. The remainder of the Daily Gathers were interactive presentations given by visiting mathematicians. Some visitors were local (from Haverford, Bryn Mawr, and Lafayette Colleges) and visitors also came from Chicago, Connecticut, Maryland, Massachusetts, Nebraska, North Carolina, Washington DC, and Washington State.

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). 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: We ordered MathILy t-shirts. At the end of the first week, we took a walk to Haverford College and back, and then gathered in our larger classroom to play a rousing game of telephone pictionary, which involved copious amounts of laughter. 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.

A few students regularly used the indoor athletic facilities. One staff member and one student went swimming most mornings. A couple of times students played frisbee.

This year we had a common room that locked, so we were able to store some games and construction sets in there. Students played card games, chess, and with ZomeTool frequently. Pandemic was played from time to time. A few students regularly practiced instruments (piano, violin). On request, a learn-to-knit session was held.

Most nights there were optional Bedtime Stories; attendance was about a third of the students and half of the staff. On free Saturdays, students asked to watch popular Miyazaki movies, and most of the program went to the large classroom with blankets and pillows for that purpose. On the last night of the program, we brought lots of puzzles and games to the common area and about half of the students played with them; many students piled into a front living room of the dorm with the program's newly acquired 20-movie Miyazaki DVD set.

Administrative matters

Facilities at Bryn Mawr: Again, everyone liked the facilities and the campus as a whole. This year we were placed in a dorm with an exclusive and lockable lounge. 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 as last year math-and-physics floor of the science building, as well as a classroom used for math department seminars.

Janitorial service is extensive at Bryn Mawr; 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.

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 2015. We agreed to continue the same basic structures, and to keep the additional AI training introduced this year.

Very few changes or tweaks were suggested, but we noted that appropriate integration of technology (*Mathematica* and Sage) into class is an ongoing challenge. Administratively, the program seemed to go more smoothly this year compared to last year.

Impact: We were pleased by the following:

- A student revealed she had ceased to enjoy and understand mathematics at her advanced school, but now loved it again because of the MathILy environment.
- A student who had been unsure whether to pursue mathematics in addition to computer science told us that she now knew enough mathematics to see that she definitely wanted to pursue both.
- Two sets of families approached staff after the program to express their gratitude for the life-changing effects they had *already* observed in their students as a result of MathILy participation.

Finances summary:

The income from student fees (some discounted) was \$105,064.

An AMS Epsilon Grant award and donations for financial aid totaled \$10,389.

Total MathILy income: \$115,453.

Administrative expenses (insurance, fliers, etc.) totaled approximately \$1900.

Total wages (instructors, PRiME, Assistant, Director) were approximately \$27,850.

Reimbursements for travel (Daily Gather speakers, instructors) were approximately \$3700.

Program expenses (supplies, program outings) were approximately \$1740.

Site (Bryn Mawr College) charges, including housing, meals, and duplications, were \$59,160.

Total MathILy expenses: approximately \$94,300.

We were fortunate to achieve savings of more than \$12,000 in wages because multiple instructors were federally supported and thus worked as volunteers. Additionally, we ran about \$9000 under budget on other wages because of personnel issues that are unlikely to be repeated.

We were also fortunate to receive in-kind donations of volunteer time and travel expenses related to the program, and software from Wolfram Research, collectively valued at \$17,500.