

MathILy 2013 Final Report

Preface

For a program organized starting in December rather than September, and made public in February rather than November, MathILy was quite successful. We faced a lot of delays and minor challenges, and still managed to hold 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: More than 100 announcement emails were sent to individuals and Math Circles and to the NExT List. Friends of MathILy posted on Facebook and Google+. MathILy has a website that is linked from the AMS summer programs page and the Math Forum summer programs page.

Print: 1200 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 109 Short Forms, 48 Not-as-Short Forms, and 39 EARs. There were 34 completed applications, of which 22 became admitted students. Of the 22 admitted students, 17 chose to attend. Two students who declined attended other national-level mathematics programs, one declined for financial reasons, and one for a combination of financial and practical reasons.

Demographics: Not-as-Short Forms originated from 19 US states and 2 foreign countries (Canada, S. Korea). 35% of Short Forms appeared to be from female applicants, 32% of EARs were from female applicants, and 44% of students who attended MathILy are female.

Financial Aid: Donations earmarked for financial aid totaled \$1600. We were able to award \$3200 in financial aid to MathILy participants because of lower-than-expected costs. At least two contacts told us that they had multiple students qualified for MathILy but could not encourage them to apply because we could not guarantee sufficient financial aid.

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).

Apprentice Instructors were Hannah Alpert (graduate student, MIT), Max Engelstein (graduate student, University of Chicago), and Emil Guliyev (recent graduate of Harvey Mudd 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 Assistant was Julia Mattes (recent graduate of Hampshire College). The Protector and Responder in the MathILy Environment (PRiME) was Reese Laviolette (advanced mathematics major at Western New England University).

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: Maine, Massachusetts, New York, New Jersey, Pennsylvania, Michigan, Colorado, Washington, and Alaska.

Ages: 15–17 years.

Academic backgrounds: Thirteen students had already taken calculus (4 had also taken multivariable calculus), and three had taken precalculus; 2 had taken AP Statistics; 2 had taken college linear algebra courses. Seven students had attended mathematics programs in previous summers.

What Happened at MathILy 2013?

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: We held a single Root class, taught by sarah-marie, Hannah, and Emil. 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, 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 40 potential topics they would be excited to learn about, from which instructors decided on a list of classes offered. These were Functional programming (Haskell)/Loops on Loops on Loops (homotopy theory), Class of chaos and fractals, Problems of Tuvalu (algorithms)/Nash Equilibrium, Projective geometry, ixevzumxgyne (cryptography)/A cure for the common absolute value (p-adics), Purely Theoretical Computers (finite-state automata), Objects of Algebra (groups, rings, and modules), Legendrian Knot Theory, Random Walks on Money (finance, probability, and brownian motion), Markov Chains/Combinatorial Optimization, Generatingfunctionology, and Lebesgue integration. Each student was placed in 5 classes according to expressed preferences. Several of the classes benefitted substantively from the students' prior work with linear algebra.

Branch Classes: We offered two Branch classes, one by sarah-marie and Max on topological graph theory and one by Tom and Hannah on the mathematics of paperfolding. There was improvement, in some students' cases significant, in the average quality of writeups from Root to Branch classes.

Pedagogy: The Root and Branch classes were all 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. The pedagogy of Week of Chaos classes varied much more, ranging from entirely student-directed explorations of material through instructors directing student explorations, instructors directing student computer explorations, and instructors directing students to develop material linearly, to interactive lecture.

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. Most visitors were local (from Bryn Mawr, Swarthmore, and Lafayette Colleges) but there were also visitors from Washington DC, Chicago, Maryland, Massachusetts, and Nebraska.

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 and instructor experiences at several colleges.

Athletics: As expected, Ultimate frisbee was a popular pastime among MathILy students, but hardly any games were played because the weather was abysmally and oppressively hot for more than two weeks. Multiple participants went for daily runs (though not together), and a few students regularly used the indoor athletic facilities. One staff member went swimming most mornings. About half of the students were involved in a choreographed human Petersen graph animation, video of which will be shown at the 2014 Joint Mathematics Meetings.

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 almost continuous laughter. The program was treated to ice-cream cones and dishes 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. Without any advance planning, the Lead Instructors ran into every single MathILy student somewhere in the city over the course of the day.

Students played board and card and video games almost every afternoon and late evening, often in an antechamber outside the PRiME’s room. Several students regularly practiced instruments (piano, saxophone, guitar). On the last night of the program, we brought lots of puzzles and games to the dorm living room and students played together into the wee hours of the morning. We held a similar, but shorter, party early in the program.

Most nights there were optional Bedtime Stories; attendance was roughly half the students.

As a collective, the students were incredibly nice. The staff kept commenting to each other on how considerate and good-natured the students were, and how well they all got along with each other.

Administrative matters

Facilities at Bryn Mawr: Everyone (staff and students and parents) agreed that the dormitory was excellent. Bathrooms were cleaned daily. Students had single rooms with window seats and air conditioners. Everyone also agreed that the campus is beautiful. A grassy area directly in front of our dorm was ideal for informal frisbee, and there are various miniature gardens all over campus, including one with a wading pool and fountain.

The classrooms we were assigned are on the math-and-physics floor of the science building, and have rows of tables with moveable chairs, overhead computer projection, and blackboards on at least two walls. Every night chalkboards were cleaned and the rooms were tidied.

Overall, the instructional staff felt that Bryn Mawr is an excellent site.

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.

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 2014. It was agreed that with (hopefully) about twice as many students, we should default to this same structure next year, including most of the details, to see which aspects of the MathILy 2013 were functions of the size and which were functions of the structure.

Minor changes to the core curriculum were suggested (such as the inclusion of some probability). Some tweaks were proposed for balancing workloads across instructional staff at various points in the program, and some additional Apprentice Instructor training was requested (by AIs).

Impact: While it seems premature to assess the impact of MathILy 2013, instructors were pleased to learn at the end that one student who had not been considering mathematics as a major or a career was now planning to pursue mathematics at least in college, and another student who had been generally interested in mathematics had become very interested in pursuing operations research.

Finances summary:

The income from student fees (some discounted) was \$74,995.

Donations earmarked for financial aid were \$1,600.

Total MathILy income: \$76,595.

Administrative expenses (insurance, fliers, etc.) totaled approximately \$1,900.

Total wages (instructors, PRiME, Assistant, Director) were approximately \$16,500.

Reimbursements for travel (Daily Gather speakers, instructors) were approximately \$500.

During-program expenses (supplies, program outings) were approximately \$750.

Site (Bryn Mawr College) charges, including housing, meals, and duplications were \$39,760.

Total MathILy expenses: approximately \$59,400.

We were fortunate to achieve savings of more than \$8,000 in wages because multiple instructors were federally supported and thus worked as volunteers. Additionally, expenses during the program were significantly lower than expected. (We do not expect that these savings will be repeated in future years.)

We were also fortunate to receive in-kind donations of volunteer time and expenses related to the program, and software from Wolfram Research, collectively valued at \$4,500.