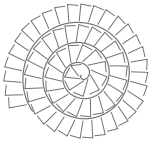

Mathematical Staircase, Inc.

MathILy-EST

MathILy-EST 2022 Final Report

Preface

The MathILy-EST Research Experience for Undergraduates (REU) was created to serve college-age students that are early in their college career (i.e., an emphasis on freshmen, but with consideration for sophomores and even graduating high-school seniors). Also, this REU runs in parallel to the 5-week MathILy program for talented high-school students. Both programs take place at Bryn Mawr College, with all the students and staff sharing the same dorm building.

Program Preparations

Promotions

Emails: Notes advertising MathILy-EST were sent to multiple email lists in the professional math community, and to (an updated list of) contacts at Historically Black Colleges and Universities, Minority Serving Institutions, the Hispanic Association of Colleges and Universities, Leadership Alliance coordinators, and to contacts at McNair programs and Black and Latinx student centers.

Fliers: No fliers were sent this year; most events were canceled because of the COVID-19 pandemic.

Webpages and links: MathILy-EST has its own webpages, and is listed on the NSF-REU pages (of course) as well as the AMS Opportunities pages, the Institute for Broadening Participation's pathwaystoscience.org, the Math Alliance website, and the Art of Problem Solving's wiki. There are also several online lists of math REUs that include MathILy-EST.

Site traffic: There were ~11,500 visitors to the MathILy-EST index page over the 2021–2022 season.

Other Activities: sarah-marie held an AoPS Math Jam on REUs in general and MathILy-EST in particular on February 23rd, which Nate also attended. There were about 40 attendees for the bulk of the time and 330 people entering/leaving over the hour-and-a-half.

Applications and Admissions

Demographics: There were 79 completed applications for the 10 REU slots. The small (for an REU) number of applications was at least partly due to ongoing effects of the COVID-19 pandemic Applicants originated from 24 US states. Of course, some states were over-represented, with at least 12 students from MA schools, 10 from NY, 9 from CA, 5 from PA, and 4 each from IL and MN.

In terms of the demographics during the stages of making decisions, we have the following percentages:

Stage in application	Female	Asian-American	African-American	Latinx	SLAC
All applicants	27%	29%	4%	10%	18%
Shortlist (16)	38%	19%	6%	25%	13%?
Accepted	40%	20%	10%	10%	40%

Every student invited to participate accepted. Two responded within 10 minutes; one responded "OMG YAY".

Personnel

Administrative: The MathILy-EST 2022 Director was Dr. Nate Harman (Postdoc at University of Michigan). Joshua Mundinger (graduate student, University of Chicago) was the Graduate Research Apprentice menTor at MathILy-EST (GReAT-EST). The PI on the NSF grant was sarah-marie belcastro (President of Mathematical Staircase, Inc.). The {MathILy, MathILy-Er, MathILy-EST} Minion was Madison Stuart.

Senior Personnel: These individuals gave advice on the construction of MathILy-EST and the NSF proposals for the grants that fund the program.
Hannah Alpert, mathematics faculty at Auburn University (MathILy-EST director 2020)
Max Engelstein, mathematics faculty at University of Minnesota (MathILy-EST director 2021)
Brian Freidin, mathematics faculty at Auburn University.
Thomas Hull, mathematics faculty at Western New England U. (MathILy-EST director 2019)
Emily Peters, mathematics faculty at Loyola University Chicago.

What Happened at MathILy-EST 2022?

Academics/Research

The research topic was combinatorial representation theory. Because of the size of the REU, Nate decided to split the students into three groups working on three separate projects. The specific topics were congruences in character tables, the tensor square conjecture, and sl_2 posets.

*Reading: L*eading up to the program the Director gave the students a reading assignment. The Director chose five research papers for students to read, split the students up into pairs and assigned one paper to each pair of students. Each paper contained relevant background information for the summer's research projects. Each pair of students made a Coauthor post summarizing their paper, and gave a presentation to the other students on it during the first week.

Mathematical Explorations: The first group looked at character tables of groups modulo prime numbers. The jumping off point was a 2020 result of Peluse and Soundararajan, who showed that for any fixed prime p the proportion of entries of the character table of the symmetric group S_n which are divisible by p tends to 1 as n goes to infinity. The REU group extended and generalized this result to wreath products, as well as to type D Weyl groups.

The second group worked on problems related to the so-called tensor square and Saxl conjectures. The Director had identified a relaxation of the Saxl conjecture he thought the students could make progress on, but unfortunately that relaxation was solved by someone else and posted to arXiv during the second week of the summer. After that this project struggled for a while to find a clear direction, but eventually a sub-problem where progress could be made was identified. They were able to verify the Saxl conjecture for partitions of Durfee square 4.

The third group investigated certain actions of the Lie algebra sl_2 on posets. There is a notion of such an action that had been studied in the 1980's and is well understood combinatorially. However, the Director observed that there is a stronger notion which is more natural from a representation theory perspective that hadn't been investigated combinatorially. This group investigated the combinatorics of such "strong" sl_2 posets, making some interesting conjectures and proving them in several special cases.

Writing (during and after): At the start of the summer most of the writing was in the form of Coauthor posts. Initially these were formal assignments: the reading and presenting assignment involved making a Coauthor post, and Nate assigned note takers each day during Week 1 to make an official Coauthor post with notes from that day. The students also made posts for the Ever-EST seminars to summarize what was discussed there.

Once the research groups formed, the Director let the different groups decide for themselves how much to use Coauthor and in what capacity. One group kept diligent notes each day on Coauthor, one barely used it, and another group was somewhere in the middle.

All of the groups also made Overleaf documents, which were viewed as being more "official" than the coauthor posts. When groups wrote up a proof they sent a draft to the GReAT-EST, who gave an initial round (or often several rounds) of feedback before they sent it to the Director who then had additional comments. In Week 6 the Director and GReAT-EST met with all of the groups to discuss the overall structure and narratives of their papers, and to help give them a coherent structure.

The three groups are writing three separate papers, the first of which appeared on the arXiv in October 2022. The other two papers still being worked on, although progress has been slow since the Fall semester started.

Professional Development

Presentations: The MathILy-EST students made several presentations as a group. Every time someone visited MathILy to give a Daily Gather, the visitor was asked to spend time with the MathILy-EST students to hear a presentation on their research. The director also arranged for several mathematicians who had written papers relevant to the projects to "visit" remotely and hear their presentations via Zoom. In preparation for speaking at the JMM and other math conferences, it was decided that all talks would be in a ~20 minute Beamer talk format.

During the last week of MathILy the MathILy-EST students gave a Daily Gather. They introduced the main objects they were studying, character tables of symmetric groups and sl_2 posets, and taught the MathILy students how to do the basic calculations with these objects and then they stated their main research questions. This took a fair amount of time to plan and rehearse, but the Daily Gather went well and everybody had a fun time.

In the last week of MathILy-EST (and the weeks after) the students prepared their abstracts for the JMM. They will be giving three 20-minute talks in a special session on undergraduate research, all of them joint. One group is additionally giving a poster presentation. All 10 students are currently planning to attend the JMM.

Software: During the first week the Director and GReAT-EST ran an Ever-EST session on LaTeX and BibTeX, as well as one on Sage. All three groups used Sage to explore their problems in different ways, and every student wrote proofs in LaTeX throughout the summer.

Other professional development: The MathILy-EST students were guided to write their own professional CVs, and heard attended a panel discussion about graduate school by the MathILy staff. There were also professional development seminars on writing papers, giving presentations, how to use MathSciNet/arXiv to look up journal articles, and one on ethics in research and mathematics. MathILy-EST participants also attended multiple MathILy Life Seminars.

Social Activities: MathILy-EST students had a lot of fun this summer. Activities included: dance parties, chess matches, a water balloon fight, pizza parties, TV/movie nights, a campfire, a hair dyeing party, and a karaoke night.

Administrative matters

Facilities and staff at Bryn Mawr: The physical environment that Bryn Mawr provided for the MathILy-EST students was excellent. Three modern "fish bowl" style conference rooms in the recently renovated section of the Park Sciences Building were provided for exclusive use by the REU students. These rooms each had floor-to-ceiling blackboards and whiteboards and a wide-screen TV for projecting computers.

Post-Processing

Post-program senior personnel meeting: After the end of the program, there was a meeting to discuss the program and to plan for next year. Brian Freidin agreed to direct the REU in 2023.

Impact: Almost all students rated all aspects of their MathILy-EST experience as very or somewhat valuable, and all ten participants stated that participation in MathILy-EST has positively influenced their career path or career. Every student visited a MathILy class, and almost all found it an interesting experience. All MathILy-EST participants reported socializing with MathILy students outside of their classes, and all found it fun, interesting, and valuable. About 95% of the MathILy students found MathILy-EST somewhat or very valuable to their MathILy experience in general, with about 85% giving these ratings on each specific aspect queried.

Finances summary:

The income from grant NSF DMS-1851842 was $44,872.
The income from grant NSF DMS-2149647 was $64,468.
Total MathILy-EST income: $109,340.
Administrative expenses were $50.
Total stipends (director, participants) were $58,000.
Total wages (MathILy director and Minion) were $3664.
Total non-wage employee expenses were $211.
Program expenses (t-shirts, pens, stickers) were approximately $398.
Travel expenses for participants were $5059.

Site expenses from Bryn Mawr were $42,528.50.
Total MathILy-EST expenses: $109,911.

The approximately $571 overage comes entirely from expenses that are not covered by NSF funding.

We were fortunate to receive donations of software from Wolfram Research worth $1812.

Note that there is still travel money in both grant budgets that will be used to help the 2020, 2021, and 2022 cohorts of students defray costs of attending the Joint Mathematics Meetings in January 2023.