PROBLEMS, PROOFS, AND PROBABILITY

The Rutgers Young Scholars Program in Discrete Mathematics

by Maya Merchant

GROWING UP, I WAS ALWAYS SURROUNDED BY MATH. WITH A MOTHER WHO HAD A PH.D. IN STATISTICS AND A FATHER WHO WAS AN ENGINEER, IT WAS NO SURPRISE THAT I WAS INTERESTED IN THE SUBJECT. BUT IT WAS WHEN I TOOK A NUMBER THEORY COURSE AT CTY THE SUMMER BEFORE MY SOPHOMORE YEAR THAT I REALIZED JUST HOW INTERESTING MATHEMATICS WAS. THAT COURSE SHOWED ME HOW SEEMINGLY INSIGNIFICANT LEMMAS COULD COME TOGETHER TO PROVE GRAND THEORIES ABOUT CONCEPTS SUCH AS PRIME NUMBERS.

I knew I wanted to delve deeper, so I was extremely excited when a friend told me about the Rutgers Young Scholars Program in Discrete Mathematics (RYSP), an intensive four-week residential summer program. The program convened on weekdays, and students returned home every weekend. In March, I sent off my application, problem set answers, and letter of recommendation from my math teacher. I was happy to receive an email of acceptance a month later.

Math for Math Lovers

At the beginning of July, I settled into a dorm on Rutgers' Busch Campus. The 18 high school students in the program were sorted into four groups, each overseen by a teaching assistant who was a Rutgers undergrad or grad student in math or computer science. The program began with a competition, with all four groups competing to solve logic-related problems as quickly as we could. As the problems became increasingly difficult, the room dissolved into

RYSP

Maya, second row, second from right, RAs (front row), and members of the 2016 Rutgers Young Scholars Program in Discrete Mathematics

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peals of helpless laughter over how badly we were all performing. We were soon begging our amused TAs to help us, but the competition helped set the tone for a program that was filled with lots of mathematics—and even more fun.

We quickly realized how intense the program really was. Each week, we took two new courses on topics that ranged from graph theory and mathematical logic to probability and number theory. The courses were taught by college professors. After each class, we worked on homework problems; the next day, we presented our solutions to the professor and our classmates. Group members collaborated on solutions, and our TAs offered guidance whenever we were completely stuck. Between class time and homework, we spent eight hours a day working on math.

Learning How to Learn

We adapted to the relative lack of free time by spending late nights in the recreation room, where we bonded over games of bridge and Mafia. In addition, our RAs organized evening activities and excursions, from watching the latest *Star Trek* movie to going for ice cream. We also spent an hour every day in the fitness center. Wherever we were, there was a sense of camaraderie as we commiserated about our classes and made the corniest math jokes imaginable.

I enjoyed learning more about math with people who felt the same as I did about it. We laughed as we learned about algorithms by throwing Angry Birds, and we sighed as we searched in vain for examples of graph isomorphism, a laborious process that involved determining whether two graphs actually had the same structure. We worked together on proofs and problems, passing scribbled equations and explanations between us like trading cards and sharing Sudoku puzzles we had made up for fun.

As we encountered increasingly difficult problems, we came to rely on each other for help in finding solutions. There were frequent discussions at lunch about who was best at graph theory, or whom to ask if you couldn't figure out a probability problem. We learned our fellow students' respective strengths and grew stronger together as we helped one another learn. I often struggled on my own to figure out the angle I needed to approach certain problems, but bouncing ideas off group members helped us all come up with solutions and improve as mathematicians.

While our TAs were always there to step in if things became too difficult, we were never given outright answers to anything. Instead, we were taught to refine our thinking and use what we had learned to tackle difficult problems. There were many days where my group members and I would spend a full hour trying to solve one problem, but it was completely worth it the next day when we presented our solutions to the class.

Problem-Solving for the Real World

One of the central aspects of the program was its focus on proofs. I had some familiarity with proofs from my number theory course at CTY, but now we delved much deeper into how a proof had to be constructed. We also identified the different theorems a good mathematician needed in her arsenal if she wanted to prove anything new. For example, the Pigeonhole Principle, which looks at how we can put n items into m containers, can be used to prove the existence—or impossibility—of a particular phenomenon.

The program also showed us how we could apply mathematics in the real world through one-hour variety sessions we attended every day after classes. While much of the mathematics we learned in class was purely theoretical, these sessions exposed us to ways we could use what we were learning to solve real problems. For example, we learned how Google uses discrete mathematics when it runs auctions to determine which advertisements it will feature on its webpages. We also heard from a member of a research team that had won a million dollars by using discrete math and statistics to improve the algorithm Netflix uses to recommend movies that appeal to individual viewers.

There were sessions in which we learned the best mathematical way to beat someone at a game, create a password, or even shape a career. During one lecture, an NSA employee explained how discrete mathematics can impact national security, stressing that the NSA needs mathematicians to crack codes used by our enemies. I never thought you could make a career solely out of mathematics unless you were a teacher, but the program gave me a completely different perspective on how I could use math outside the classroom, whether by employing cryptology to protect national security or by applying game theory to analyze the economy.

The Young Scholars Program changed so much of the way I think about mathematics. It made me more curious, awakened me to the possibility of a career in math, and made me realize how much I love the subject. I currently represent my school on our Math League team, and I am sure that I want to pursue mathematics when I go to college. Most importantly, the program helped me forge lasting friendships with other students who showed me that I was not alone in my love for mathematics. ■

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Learn more about the RYSP at dimacs.rutgers.edu/ysp.