

Teaching Statement

Catherine Ray

As someone who entered academia as an outsider with a highly nontraditional background, I go out of my way to present mathematics in ways that are accessible to everyone. Mathematics is a visual, interactive, intuitive, and artistic experience, and most importantly it is a narrative one.

I often introduce the material as though we, the class, are discovering it together. We begin with examples and historical motivation, and only from there move to definitions and theorems. This recapitulates how mathematics was discovered historically. I want the students to have this same experience. Reading the work of Euler, we see that he is playing with examples until he states at the very end the theorem he deduced from those emergent patterns. Through this direct interaction with the object of interest, students can see the patterns that lead to understanding.

I like to have the students learn by doing, and then help them unite their observations into a coherent whole. As an example, when I teach linear algebra I like to begin by connecting it to image processing. I want the students to understand how a matrix affects the size, position, and rotation of images. To do so, I have my students use the explorable explanation *The Magnificent 2D matrix* by my friend and master expositor Nicky Case, which is publicly available alongside many other similarly accessible tales through their website <https://ncase.me/>. When the students change the 2D matrix, they can see what the matrix does visually. This requires no mathematical background. Once they understand intuitively the transformative properties of an matrix, I like to introduce the concept of a determinant of a matrix M as the volume of a unit cube transformed by that M . I then introduce the defining properties that characterize the absolute value of the determinant visually, for example, the invariance of the determinant when swapping rows corresponds to the invariance of volume when we swap “width” and “height”. In this way, they can survey an entire system of discoveries that follow from a single essential idea, volume, which, in their logical order, harmony, and brilliance, appear transparent and as an organic whole, like a painting before the mind’s eye.

As an example of presenting material with historical context, when I am teaching Real analysis, I split my exercises between the standard book, Rudin, and the corresponding chapter in *Introduction to Analysis by its History*. I also make sure to provide visual text books when possible, such as *Visual Complex Analysis*.

I get to know my students so that I can tailor the material to their interests directly. For example, if I learn that many of my students have a biology or psychology interest, I will find a way to cover *p-hacking*, that is, data dredging that does not take into account the necessary adjustment of probabilistic significance. Learning mathematics contextually in this way, students can both understand the importance of mathematics in everyday life, and form scepticism over news presented without statistical backing.

I also really enjoy working with students one-on-one, responding to their individual needs. For example, I have provided my Math Circles, REU, and DRP students with: sets of puzzles to play with, objects of direct interest, a question to guide their play, or sequential learning of concepts guided by resources on my website rin.io/resources. This works for students of all levels, from beginners to graduate students.

I strive to make sure people with any background can get acquainted with both the methodology of mathematics and the immersive feeling of doing mathematics.

EXTRACURRICULARS

Mentorship of Postbaccalaureate Students. The Causeway Program is a year-long postbaccalaureate program in mathematics that seeks to increase the number of graduate students in mathematical sciences from underrepresented groups. This is a rich and interesting group, usually from complex circumstances. I've enjoyed helping to welcome them into our research environment. These students are often interested in physics, computer science, or entrepreneurship, and as someone with a background in all three, I've found it exciting to work with them.

From Engineers to Laypeople. For engineers and scientists, I helped found and fund the *Topos House*, which hosts 6-12 scientists in a central house dedicated to creating the optimal conditions for interdisciplinary work focused around mathematics. I also connect people to Davide Radaelli and Nic Ford, two people teaching undergrad and grad level maths to engineers, <https://nicf.net/about/>. I am currently running an ongoing comic called *re-search* about the joy of understanding a concept for the first time, which is aimed toward capturing the joy of doing mathematics for laypeople.

Expository Blog. It's borderline impossible to get comfortable with many of the tools in modern mathematics without having a professor that wants to spend a decent amount of time working with you. This is inaccessible to most people. My blog *good fibrations* aims to bridge that gap. Here is an example of a review of my expository style by someone from a liberal arts college who used it as a way to prepare for graduate school during the pandemic:

“I really like your drawings and I really really like your chatty, fun happy writing style which makes learning feel more safe and less hostile.”

Mental Health Support. I encourage students to form healthy boundaries and establish their work-life balance to prevent burnout. The graduate students at Northwestern who entered during the pandemic did not form social groups. To combat this, I started a funded program called *the Buddy Program* pairing first and second year graduate students with older graduate students to meet once a quarter for mental health check-ups. I am also a *TGS Peer Mentor* in the office of Diversity and Inclusion, which helps first-year PhD students from diverse backgrounds become acclimated to Northwestern. Toward supporting mental health of the graduate students, I was nominated treasurer of *The Graduate Life Appreciation Fund* for enriching the climate of the graduate program at Northwestern. This fund helps students participate in activities they might not be able to afford otherwise.

