**Epic Math Battles: Counting vs. Matching**

Which technique is mathematically superior? The audience will judge of this tongue-in-cheek combinatorial competition between the mathematical techniques of counting and matching. Be prepared to explore positive and alternating sums involving binomial coefficients, Fibonacci numbers, and other beautiful combinatorial quantities. How are the terms in each sum concretely interpreted? What is being counted? What is being matched? Which is superior? You decide.

**The Combinatorialization of Linear Recurrences**

Binet’s formula for the nth Fibonacci number,

$$F\_{n}= \frac{1}{\sqrt{5}}\left[\left(\frac{1+\sqrt{5}}{2}\right)^{n}-\left(\frac{1-\sqrt{5}}{2}\right)^{n}\right]$$

is a classic example of a closed form solution for a homogenous linear recurrence with constant coefficients. Proofs range from matrix diagonalization to generating functions to strong induction. Could there possibility be a better way? A more visual approach? A combinatorial method?

This talk introduces a combinatorial model using weighted tiles. Coupled with a sign reversing involution, Binet’s formula becomes a direct consequence of counting exceptions. But better still, the weightings generalize to find solutions for any homogeneous linear recurrences with constant coefficients.

**Proofs That Really Count**

Every proof in this talk reduces to a counting problem---typically enumerated in two different ways. Counting leads to beautiful, often elementary, and very concrete proofs. While not necessarily the simplest approach, it offers another method to gain understanding of mathematical truths. To a combinatorialist, this kind of proof is the only right one. I have selected some favorite identities using Fibonacci numbers, binomial coefficients, Stirling numbers, and more. Hopefully when you encounter identities in the future, the first question to pop into your mind will not be "Why is this true?" but "What does this count?"

This talk is a “Choose your own adventure”™ where the content is guided by the input and desires of the audience.

**Digraphs and Determinants**

``There is no problem in all mathematics that cannot be solved by direct counting`` (Ernst Mach)

In linear algebra, you learned how to compute and interpret $n × n$ determinants. Along the way, you likely encountered some interesting matrix identities involving beautiful patterns. Are these determinantal identities coincidental or is there something deeper involved?

In this talk, I will show you that determinants can be understood combinatorially by counting paths in well-chosen directed graphs. We will work to connect digraphs and determinants using two approaches:

* Given a ``pretty`` matrix, can we design a (possibly weighted) digraph that clearly visualizes its determinant?
* Given a ``nice`` directed graph, can we find an associated matrix and its determinant?

Previous knowledge of determinants is an advantage but not a necessity. This will be a hands-on session, so bring your creativity and be prepared to explore the mathematical connections.